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QUALIFICATION TEST REPORT,
VOLUME XXXIX.

VIBRATION AND MISSION SIMULATION TESTING
ON ENGINE 828
XF107-WR-400 CRUISE MISSILE ENGINE.

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PREFACE

This document, Volume XXXIX of the Qualification Test Report, Vibration and Mission Simulation Testing on Engine 828, XF107-WR-400 Cruise Missile Engine, is one of several reports that will be submitted under CDRL 95, Contract N00019-78-C-0206, describing the results of the Qualification Tests. Volumes I through XV will cover the Phase I engine qualification. EMI/EMC and Nonoperating Shockloads, both for the F107-WR-400 engine, will be covered in Volumes XVI and XVII. Component Qualification Tests will be discussed in Volumes XVIII through XXVI. Structural Qualification results will be presented in Volumes XXVII through XXX. Volumes XXXI through XL will present results of the Phase II engine qualification.

SECTION 1

INTRODUCTION

1.1 PURPOSE OF TEST

Engine 828 was tested at Bendix Aerospace Systems Division - Ann Arbor, Michigan, as Engine 828/build 4 and at the Arnold Engineering Development Center (AEDC), Tullahoma, Tennessee, as Engine 828/build 6. The tests were performed to demonstrate F107-WR-400 engine compliance with environmental vibration and mission simulation requirements as specified in the Prime Item Development (PID) Specification 24235WR9501B and the Qualification Test Plan (QTP), CMEP 91-4043G, Report No. 78-145-8.

1.2 DESCRIPTION OF TEST ENGINE

Engine 828/builds 4 and 6 was an XF107-WR-400 engine, assembled in accordance with Top Assembly Drawing and Parts List 1029110-108.

1.3 DISPOSITION OF TEST ENGINE

After completion of the planned testing at AEDC, Engine 828/build 6 was returned to WRC, where a post-test teardown and inspection was performed. The engine has since been moved into bonded storage at WRC, Walled Lake.

1.4 SUMMARY

1.4.1 Prequalification Testing At WRC

Engine 828 did not exhibit any significant operational irregularities on either build 4 prior to shipment to Bendix Aerospace Systems or on build 6 before reshipment to AEDC.

As shipped to Bendix Aerospace Systems for environmental vibration testing, conditionally approved discrepancies against the engine included the incorporation of an unapproved ECR dealing with the modified No. 4 carbon seal shield, the incorrect routing of the fuel control unit temperature sensor lead, the use of an unapproved sealant and an unapproved adhesive internal to the engine, and the installation of a P/N 36240 fuel control unit prior to Government approval.

After the replacement and testing at WRC of hot section hardware damaged during the initial attempt to conduct the hot-day mission simulation test at AEDC, the engine was returned to AEDC on build 6 with conditionally approved discrepancies. These discrepancies included sealants and adhesives internal to the engine, the use of a P/N 36240 fuel control unit, and the use of a P/N 34733 hot gas tube collar.

1.4.2 Qualification Testing At Bendix Aerospace

Engine 828/build 4 was vibration tested at Bendix Aerospace Systems - Ann Arbor, on 14 and 15 January 1980. The testing consisted of two components, 30 minutes of random frequency vibrations along each of the principle engine axes, and sinusoidal vibratory sweeps for 30 minutes at constant input levels along the lateral and vertical axes. No significant hardware irregularities were noted during or after the testing.

1.4.3 Qualification Testing At AEDC

The initial attempt to conduct the mission simulation tests on Engine 828/build 4 at AEDC was curtailed on 25 February 1980 when an increase in measured EGT and an engine speed rematch were noted (reference Report DAL 8012).

Mission simulation testing at AEDC recommenced on 2 April 1980, the engine having been returned, after repairs, as Engine 828/build 6. Only one incident of any significance occured during the hot and cold day mission cycles, that being the failure of the fuel control unit early in the hot day cycle. The failed unit was replaced, the test sequence was restarted and run through completion as scheduled on 16 April 1980.

1.4.4 Post Mission Simulation Testing Teardown Inspection

Following the return of Engine 828 to WRC, a thorough teardown inspection, conducted on 23 and 24 April 1980, revealed no component failures or indications of impending component failures.

1.5 RECOMMENDATION

It is recommended that the testing completed with Engine 828 be accepted as evidence that the F107-WR-400 engine meets or exceeds the requirements for environmental vibration exposure and mission simulation testing as set forth in the PID Specification, 24235WR-9501A, and the Qualification Test Plan, CMEP 91-4043G, Report No. 78-145-8.

SECTION 2

PREQUALIFICATION TESTING AT WRC

2.1 SUMMARY

Engine 828 required four builds prior to shipment, on 2 January 1980, to Bendix Aerospace Systems - Ann Arbor to commence qualification testing. The initial "green run" of the engine was performed on build 1. Build 2 involved a penalty run to evaluate the combustor temperature profile which had been modified following build 1. The combustor was replaced on build 3. Build 4 involved the final testing of the engine prior to shipment.

The engine was returned to WRC on 27 February for investigation into the cause of a sharp increase in measured EGT noted during the initial attempt to conduct the hot day mission simulation test at AEDC. Several engine components were observed to have sustained heat damage. The fuel slinger and the combustor/first nozzle assembly were replaced and the engine reassembled to prepare for retesting and reshipment to AEDC. Testing on build 5 included an EGT survey on the new combustor and disassembly for inspection of the new parts. The final run prior to reshipment was performed on build 6. The engine was reshipped to AEDC on 25 March 1980 to recommence the mission simulation tests.

2.2 PROCEDURES

2.2.1 Test Article Description

2.2.1.1 Physical Configuration

Engine 828 was an XF107-WR-400 engine assembled in accordance with Top Assembly Drawing and Parts List 1029110-108.

The engine was delivered on build 4 with discrepancies as noted on Inspection Rejection Report (IRR) 92153. IRR 92153, shown in Figure 2-1, notes the incorporation of an unapproved ECR dealing with the modified No. 4 carbon seal shield, the incorrect routing of the fuel control unit temperature sensor lead, the use of an unapproved sealant when the accessory drive bearings were installed and an unapproved adhesive when the No. 5 carbon seal was installed and the installation of a P/N 36240 fuel control unit prior to Government approval. These discrepancies, conditionally approved by letter from the Administrative Contracting Officer (Figure 2-2), were applicable to the engine both as shipped to Bendix Aerospace-Ann Arbor for vibration testing and as shipped to AEDC for the initial attempt to conduct the mission simulation tests.

The engine was returned to AEDC on build 6 with conditionally approved discrepancies which included the sealant and adhesive used during the installation of the No. 5 carbon seal and the accessory drive bearings, the use of a P/N 36240 fuel control unit, and the use of a P/N 34733 hot gas tube collar. These discrepancies are listed in IRR 94579 (Figure 2-3) and were also conditionally approved by letter from the Administrative Contracting Officer (Figure 2-4).

2.2.1.2 Functional Description

Engine 828/build 6, as shipped to AEDC for mission simulation testing, had the following functional parts measurements and major components identification:

- Tailpipe Area: 31.85 in^2
- First Nozzle: S/N WL-1014, $A_{eff} = 3.155\ in^2$, $Q = 1.681$
- Second Nozzle: S/N WL-101, $A_{eff} = 7.766\ in^2$
- Third Nozzle: S/N GDB-69, $A_{eff} = 12.186$
- Fuel Control Unit: S/N RF-1443446 (Later replaced at AEDC by fuel control unit S/N 1443454).
- Oil Pump: S/N HCB-294
- Gearbox: S/N B-42
- Ignition Generator/Exciter: S/N BX00175

Engine weight, as shipped to Bendix Aerospace for vibration testing on build 4, was 142.5 lbf with a fully serviced lubrication system and residual fuel, but with no airframe generator installed. The specification weight for an F107-WR-400 airframe generator, as installed during the vibration testing, is 16.5 lbf.

Engine weight, as shipped to AEDC on build 6, was 140.9 lbf with a fully serviced lubrication system and residual fuel but without an airframe generator installed.

The apparent discrepancy in engine shipping weights is largely due to the fitting of both an expended engine starting cartridge and oxygen bottle for the vibration testing and their absence when the engine was shipped to AEDC.

Engine run time at WRC prior to shipment as Engine 828/build 4 was 6.62 hours with 21 starts. Engine run time at WRC on builds 5 and 6 was 4.65 hours with 14 starts. Accumulated run time at WRC and AEDC, prior to shipment back to AEDC to re-attempt the mission simulation testing, was 19.16 hours with 38 starts including one cartridge-initiated start.

Engine performance instrumentation, detailed in Run Program QT-21, included three HP compressor discharge temperature (CDT) thermocouples, three LP turbine discharge temperature thermocouples (electrically coupled to produce an average temperature output), three bypass mixing plane temperature thermocouples, and three additional LP turbine discharge temperature thermocouples providing individual temperature outputs. Data from this instrumentation is used to compute TIT. Additionally, IP bleed airflow pressure and temperature measurement instrumentation was installed on the engine.

2.2.2 Test Facility

Engine 828 completed the final runs prior to shipment on both build 4 and 6 in test cell B-4 at WRC. This test cell is described in paragraph 3.3.3 and Appendix A of the Acceptance Test Procedure for YF107 Turbofan Engines, Revision A, CMEP 92-1022 (Report No. 78-183). Run Program QT-21 is presented in Appendix B of this document.

2.2.3 Test Procedures

The tests conducted at WRC were performed in accordance with the requirements of the PID Specification (24235WR9501B), the QTP, and Run Program QT-21.

2.3 RECORD OF TESTING AT WRC

Final testing at WRC, prior to shipment to the qualification test facilities, was performed on two separate occasions. The first final test sequence was performed prior to the inital shipment to Bendix Aerospace on build 4. The second final test sequence occurred before reshipment to AEDC as build 6.

2.3.1 Record of Testing on Build 4 Prior to Shipment

Engine 828/build 4 was installed in Test Cell B-4 on 14 December 1979 for the final run prior to shipment to Bendix Aerospace - Ann Arbor. Engine monitoring instrumentation was attached, the lubrication system was serviced with 750 ml of MIL-L-23699 oil (Exxon batch 219) and the fuel system was purged with RJ-4 fuel. The engine was then airmotored to verify instrumentation and oil pressure response.

The engine was started to conduct the planned five-minute leak check run (1.2 seconds to light, 6.6 seconds to idle). No fluid leakage was noted after completion of the run and 300 ml of MIL-L-23699 oil (Exxon batch 219) were added to the engine oil reservoir.

The engine was started to perform the scheduled six-point power calibration used to determine the maximum governed HP spool speed trim point (1.4 seconds to light, 6.4 seconds to idle). After completion of the calibration run, the oil was drained, weighed (923.7 grams with pan) and returned to the engine. The fuel control unit trim adjustment motor was installed at that time in preparation for the maximum governed HP spool speed adjustment.

The engine was restarted (1.5 seconds to light, 6.7 seconds to idle) and accelerated to a PLA setting of +3.65 Vdc. The fuel control unit was trimmed, at that setting, to a maximum governed HP spool speed of 63,000 rpm with a calculated TIT of 1795°F. After completion of the speed adjustment, the setting device was removed.

The engine was then started (1.4 seconds to light, 6.4 seconds to idle) and accelerated to the maximum PLA setting to verify the maximum trimmed HP spool speed adjustment. The trimmed HP spool speed was acceptable at 63,000 rpm.

Without any further interruption, the engine was subjected to the slow transient run, the performance calibration and the fast transient run as specified in the final run planning. The engine was then shut down and the oil was drained and weighed (892.2 grams including the drain pan). Oil consumption was calculated to have been 0.007 gal/hr.

After reservicing of the oil system with 765.6 grams of new MIL-L-23699 oil (Exxon batch 219), the engine was started (1.3 seconds to light, 6.3 seconds to idle) and a 30-minute oil consumption run was performed. Post-engine shutdown oil weight was 748.5 grams with oil consumption calculated to have been 0.009 gal/hr.

The engine was reserviced with 750 ml of new MIL-L-23699 oil and a final five-minute leak check run conducted. A post-run inspection revealed no fluid leakage. The engine was removed from the test cell on 14 December 1979 and prepared for shipment to Bendix Aerospace to conduct qualification vibration testing.

2.3.2 Record of Testing on Build 6 Prior to Shipment

The initial attempt to conduct the hot and cold day mission simulation tests at AEDC was aborted on 25 February 1980, when a change in engine spool speed match, coupled with an increase in measured EGT, was noted. A subsequent teardown investigation at WRC revealed two burned first nozzle vanes.

The engine was reassembled after replacement of the fuel slinger and the combustor/first nozzle assembly. Subsequent to a performance calibration and teardown to evaluate the newly installed combustor on build 5, the engine was assembled on build 6 to conduct the final pre-qualification acceptance testing.

Engine 828/build 6 was installed in test cell B-4 on 24 March 1980. Engine monitoring instrumentation was attached, the lubrication system was serviced with 750 ml of MIL-L-23699 oil (Exxon batch 219) and the fuel system was purged with RJ-4 fuel. The engine was then airmotored to verify instrumentation and oil pressure response.

The engine was initially started to conduct a five-minute leak check run (2.5 seconds to light, 7.6 seconds to idle) at idle speed. Several external oil leaks were noted and repairs were attempted after shutdown. The engine was then serviced with an additional 200 ml of MIL-L-23699 oil (Exxon batch 219).

The engine was restarted (1.4 seconds to light, 7.2 seconds to idle) and accelerated to an HP spool speed of 60,000 rpm for an additional leak check run. Some additional fluid leakage was observed and repairs were undertaken again.

The engine was started to perform the scheduled six-point power calibration used to determine the maximum governed HP spool speed trim point (1.4 seconds to light, 7.0 seconds to idle). After completion of the calibration run, the oil was drained, weighed (889.8 grams with pan) and returned to the engine. The fuel control unit trim adjustment motor was installed at that time in preparation for the maximum governed HP spool speed adjustment.

The engine was restarted (1.3 seconds to light, 7.0 seconds to idle) and accelerated to a PLA setting of +3.65 Vdc. The fuel control unit was trimmed, at that setting, to a maximum governed HP spool speed of 62,840 rpm. Following shutdown, the adjustment motor was removed.

The engine was restarted to check the adjusted maximum HP spool speed (1.5 seconds to light, 7.2 seconds to idle). At a PLA setting of +3.65 Vdc the maximum trimmed HP spool speed was noted to be acceptable at 62,850 rpm. The engine was then returned to idle and shutdown.

The engine was restarted, taking 1.3 seconds to light and 6.8 seconds to attain idle. The slow transient, the performance calibration, and the fast transient runs were completed according to the final run planning, after which the engine was returned to idle, shutdown and the oil drained. Oil consumption during the engine trimming procedure and the final run was calculated to have been 0.013 gal/hr. No external fluid leakage was noted after shut down.

The engine was reserviced with new MIL-L-23699 oil, (Exxon batch 219, 725.3 grams including pan). The engine was then restarted (1.4 seconds to light, 6.8 seconds to idle) to conduct the schedu-

led 30-minute oil consumption run. At the completion of this test, the oil was drained, weighed (685.9 grams including drain pan) and oil consumption was calculated to have been 0.021 gal/hr. The engine was then reserviced with 750 ml of MIL-L-23699 oil (Exxon batch 219).

Performance levels at AEDC often exceed those observed at WRC. Therefore, it was determined that it would be advantageous to trim the engine to a point that would yield only 100 percent of the minimum specification thrust, rather than a value slightly in excess of the specification minimum, as has been the habit with the Phase II Qualification Test engines. This limitation was initiated to prevent the recurrence of exessive TIT values during the hot day mission cycle testing at AEDC.

The fuel control unit trim adjustment motor was reinstalled and the engine restarted (1.6 seconds to light, 7.2 seconds to idle). At a PLA setting of +3.65 Vdc, the fuel control unit was trimmed to yield an HP spool speed of 62,600 rpm at a calculated TIT of 1805°F. The engine was then shut down and the trimming motor was removed.

The engine was restarted (1.4 seconds to light, 7.4 seconds to idle) and accelerated to a PLA setting of +3.65 Vdc to check the trimmed HP spool speed. Maximum HP spool speed, as trimmed, was acceptable at 62,610 rpm. This setting produced a maximum thrust value equal to the specification value.

After shutdown the oil reservoir was "topped off" with 100 ml of new MIL-L-23699 oil (Exxon batch 219). The engine was then removed from the test cell and prepared for shipment to AEDC to recommence the scheduled hot and cold day mission simulation testing.

2.4 ANALYSIS OF ENGINE PERFORMANCE AS SHIPPED TO AEDC ON BUILD 6

Engine performance during the prequalification acceptance run is summarized and compared to the specification limits for sea level, static, standard day conditions in Table 2-I. Figures 2-5 through 2-15 present basic engine performance data obtained during the prequalification testing at WRC in detailed comparison with the specification requirements. Figure 2-16 presents the EGT profile and Figure 2-17 reproduces the correlation curve, used in computing TIT, of the average of the three flight EGT thermocouples and the average of the 72-element EGT thermocouple rake during the prequalification testing at WRC. Figures 2-16 and 2-17 present data from build 5, as specialized instrumentation required to obtain the data presented there is not installed for the prequalification acceptance test. In absence of contrary indications, these parameters are assumed to have the same values for build 6.

2.4.1 Oil Consumption

Oil consumption, measured during the 30-minute final oil consumption run at WRC, was calculated to have been 0.021 gal/hr. The weight of the oil consumed was 39.4 grams at a density of 0.989 gm/ml.

2.4.2 Performance Assessment

Engine 828/build 6, as fitted with a 31.85 in^2 jet nozzle, was trimmed at WRC to an HP spool speed of 62,610 rpm at a PLA setting of +3.65 Vdc. Thrust, as trimmed, was measured to be 640 lbf with a calculated maximum turbine inlet temperature (TIT) of 1805°F and an EGT of 1020°F at the maximum PLA setting. Specific Fuel consumption was 3.36 percent below the specification maximum value at the maximum continuous thrust rating. SFC at 90 percent and 75 percent maximum continuous thrust ratings was below the specification maximum limits by 2.69 and 1.62 percent, respectively. Table 2-I demonstrates that all critical performance parameters remained within limits.

2.5 CONCLUSIONS

Engine 828/build 4, at the conclusion of the final testing at WRC, was considered acceptable to conduct vibration testing at Bendix Aerospace-Ann Arbor and mission simulation testing at AEDC. Following the replacement of hardware damaged during the initial mission simulation test attempt, the engine was rerun through the final testing at WRC and deemed acceptable to recommence the hot and cold day mission simulation tests.

TABLE 2-I. ENGINE 828/BUILD 6, PERFORMANCE SUMMARY

ENGINE MODEL XF107 - WR-400		
DATA CORRECTED TO SEA LEVEL, STATIC, STANDARD DAY CONDITIONS		
		INDICATE IF DEVIANT
I. AT TRIM SPEED OR 3.65 VDC TO FUEL CONTROL ACTUATOR		
Thrust Fn/δ (100% FM min - INDICATE % FM)[1]	100.8	
HP Speed $N_2/\sqrt{\theta}$ (63200 rpm max)	62610	
LP Speed $N_1/\sqrt{\theta}$ (34755 rpm max)	33400	
EGT EGT/θ (1130°F max)	1020°F	
TIT/θ (1925°F)	1805°F	
II. At Fn/δ = Fm		
EGT EGT/θ (1130°F max)	1010°F	
SFC SFC/$\theta^{.67}$ (100% SFCM max - INDICATE % SFCM)	-3.36	
Airflow $W\sqrt{\theta}/\delta$ (14.0 lbm/sec max) (13.19 lbm/sec min)	13.50	
HP Speed $N_2/\sqrt{\theta}$ (63200 rpm max)	62400	
LP Speed $N_1/\sqrt{\theta}$ (34755 rpm max) (31445 rpm min)	33200	
III. At Fn/δ = 90% Fm		
EGT EGT/θ (1060°F max)	985°F	
SFC SFC/$\theta^{.67}$ (97.4% SFCM max - INDICATE % SFCM)	-2.69	
Airflow $W\sqrt{\theta}/\delta$ (13.39 lbm/sec max) (12.61 lbm/sec min)	12.95	
HP Speed $N_2/\sqrt{\theta}$ (62883 rpm max) (60417 rpm min)	61300	
LP Speed $N_1/\sqrt{\theta}$ (33180 rpm max) (30020 rpm min)	31800	
IV. At Fn/δ = 75% Fm		
EGT EGT/θ (960°F max)	940°F	
SFC SFC/$\theta^{.67}$ (94.1 % SFCM max - INDICATE % SFCM	-1.62	
Airflow $W\sqrt{\theta}/\delta$ (12.46 lbm/sec max) (11.74 lbm/sec min)	12.00	
HP Speed $N_2/\sqrt{\theta}$ (60894 rpm max) (58530 rpm min)	59500	
LP Speed $N_1/\sqrt{\theta}$ (31080 rpm max) (28120 rpm min)	29800	

[1] FM is minimum thrust at the maximum continuous rating at sea level static as specified in Table 1 of PIO Spec 24235WR9501A SCN 010 dated 17 October 1978.

[2] SFCM is maximum SFC at condition 1.

Cm 12/17

INSPECTION REJECTION REPORT — WILLIAMS RESEARCH CORPORATION — IRR № 92153

PART NO: 1029110-108 | CHG LTR: A | DATE: 11-29-79 | PAGE 1 OF

PART NAME: TURBOFAN ENG.

SER NO: 828

W O NO: 436338 | SPLIT

LAST OPER: 0002 | CONTR PROJ NO: 267290-099

DATA	M/H HRS	MRB HRS
ENGRG		.4
INSP Q A		.3
TOT HRS		.7

REJECTION TYPE/ORIGIN

TYPE		ORIGIN			
IN PROC ADV		ASSEMBLY		SHOP VENDOR	
FINAL ~~ASSY~~	X	CUSTOMER		H & O	
REWORK LATENT		ENG TEST	X	TL GAGE	

QTY: 1 | QTY ACC: 0 | QTY REJ: 1

VENDOR NAME: WRC | BUYER

SOURCE NO: 99999

P O NO | ITEM No | RCT NO | DATE RECVD

ITEM NO	SPECIFICATION	S/N	B/P LOC	DISCREPANCY CHECKS	OCCUR RENCES	DEFECT CODE	PMR REVIEW USE	RWK	SCRAP	MRB	L.A. LEVEL
1	ECR# 79-00619 INSTALLED	828		ECR# 79-00619 NOT APPROVED	1/1	F				X	3
2	ENG CONFIGURATION	828		FUEL CONTROL TEMP. SENSOR LEAD ROUTED IN FRONT OF FUEL TUBE (ECU TO FUEL SHUTOFF) INSTEAD OF BEHIND IT	1/1	F				X	3

INSPECTOR: R. L. Cole | PMR ACTION: SUBMIT TO MRB | INSP SUPVR: D. C. Greene / Q.C.

DISPOSITION INSTRUCTIONS:

1-5 USE AS IS PER ACO LETTER DATED 12-19-79

SKETCH OF DISCREPANCY

DISPOSITION SUMMARY	USE AS IS	REWORK	SCRAP
	1		

RESPONSIBILITY	WRC	VENDOR	REWORK NO
	X		

PROCUREMENT DEPARTMENT: BUYER | DATE

RETURN TO VENDOR: REWORK | REPLACE — RETAIN AT WRC: REWORK | SCRAP — CHARGE: WRC | VENDOR

MATERIAL REVIEW BOARD

SIGN | DATE

WRC ENGINEERING: SIGN Bob Phillips DATE 12/20/79

WRC QUALITY ASSURANCE: SIGN Kurtz DATE 12/20/79

CUSTOMER QUALITY ASSURANCE: SIGN [illegible] DATE 12/20/79

INSP ION

FORM QC393 (7/79)

Figure 2-1. Inspection Rejection Report No. 92153
(Page 1 of 2)

INSPECTION REJECTION REPORT — CONTINUATION

PAGE 2 OF

PART NUMBER 1029110-101

IRR 92153

ITEM NO	SPECIFICATION	S/N	M/P LOC	DISCREPANCY CHECKS	OCCURENCES	DEFECT CODE	PMR REVIEW USE	PMR REVIEW RWK	PMR REVIEW SCRAP	PMR REVIEW MRB	C/A LEVEL
3.	ENG CONFIGURATION	828		P/N 23240 SEALANT USED ON #5 CARBON SEAL O.D. NOT APPROVED PER P.I.D. SPEC. 3.3.4.1.1	1/1	F				X	3
4.	ENG. CONFIGURATION	828		P/N 36377 ADHESIVE USED ON ACC. DRIVE BEARINGS NOT APPROVED PER P.I.D. SPEC. 3.3.4.1.1	1/1	F				X	3
5.	ENG CONFIGURATION	828		P/N 36240 - FUEL CONTROL - INSTALLED IN PLACE OF 23860 FUEL CONTROL (PRIOR TO GOVT. APPROVAL)	1/1	F				X	3

CONTINUED DISPOSITIONS

MATERIAL REVIEW BOARD

SIGN	DATE	WRC ENGINEERING SIGN	DATE	WRC QUALITY ASSURANCE SIGN	DATE	CUSTOMER QUALITY ASSURANCE SIGN	DATE

INSP TION

QC396 (7 79)

Figure 2-1. Inspection Rejection Report No. 92153 (Page 2 of 2)

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

DCRO-GTCA/WR (J. Boedecker/Ext 352/imf) 19 Dec 1979

SUBJECT: Shipping Authorization, Engine S/N 828, Contract N00019-78-C-0206

Mr. Dave Cooper
CMEP Contract Administration
Williams Research Corporation
2280 W. Maple Road
Walled Lake, MI 48088

Dear Mr. Cooper:

You are hereby authorized to ship subject engine via air shipment on a DD Form 1149 to AEDC, Tullahoma, Tennessee.

It is noted that this engine deviates from specification and QT Test Plan requirements as documented on IRR 92153. This authorization is granted notwithstanding the deviant condition to provide for further testing of this engine.

This letter should not be construed as waiving any specification of QT requirements or any other Government rights established by the contract. The only purpose of this letter is to acknowledge the above cited deviations and to provide shipping authorization. This authorization is granted for the sole convenience of the contractor.

This letter may be used to close the above referenced IRR per your internal requriements.

JOHN A. APPLIN
Administrative Contracting Officer
DCAS-WRC Residency

cc: DCRO-GTQF/WR (C.C. Davis, Jr.)
JCM-285 (Major Rice)
ASD/YZ107 (Col. Goetz)
WRC (L. Scheen)

Figure 2-2. Administrative Contracting Office (ACO) Letter Permitting Shipment of Engine 828/Build 4 to Bendix Aerospace and AEDC

CM 3125

INSPECTION REJECTION REPORT
WILLIAMS RESEARCH CORPORATION

IRR № 94579

PART NO 1029110-108 | CHG LTR A | DATE 3-24-80
PART NAME TURBOFAN | PAGE 1 OF
SER NO 828
W O NO 438097 | SPLIT
LAST OPER 0002 | CONTR/PROJ NO 267290-99

DATA	PMR HRS	MRB HRS
ENGR'G		.4
INSP Q A	1.2	1.4
TOT HRS		1.8

REJECTION TYPE/ORIGIN

TYPE		ORIGIN			
IN PROC ADV		ASSEMBLY		SHOP VENDOR	
FINAL RECV'G	X	CUSTOMER		R & D	
REWORK LATENT		ENG TEST	X	TL GAGE	

QTY 1 | QTY ACC 0 | QTY REJ 1

VENDOR NAME WRC
SOURCE 99999
BUYER
P O NO | ITEM NO | RCT NO | DATE RECVD

ITEM NO	SPECIFICATION	S N	B.P. LOC	DISCREPANCY CHECKS	OCCUR-RENCES	DEFECT CODE	PMR REVIEW USE	RWK	SCRAP	MRB	Q.A. LEVEL
1	ENG CONFIGURATION	828		P/N 23240 SEALANT USED ON #5 CARBON SEAL O.D. NOT APPROVED PER PID SPEC 3.3.1.1.1.	1/1	F				X	1
2	ENG CONFIGURATION	828		P/N 36377 ADHESIVE USED ON ACC DRIVE BRGS. NOT APPROVED PER P.I.D. SPEC 3.3.1.1.1	1/1	F				X	1

INSPECTOR Roger L. Cook | PMR ACTION SUBMIT TO MRB | INSP SUPVR [signature]

DISPOSITION INSTRUCTIONS

1-4 USE AS IS PER ACO LETTER DATED 25 MAR 1980.

SKETCH OF DISCREPANCY

DISPOSITION SUMMARY	USE AS IS	REWORK	SCRAP	RESPONSIBILITY	WRC	VENDOR	REWORK NO
	1				X		

PROCUREMENT DEPARTMENT: BUYER | DATE
RETURN TO VENDOR: REWORK | REPLACE
RETAIN AT WRC: REWORK | SCRAP
CHARGE: WRC | VENDOR

MATERIAL REVIEW BOARD

SIGN | DATE
WRC ENGINEERING: SIGN Bob Hilley DATE 5/27/80
WRC QUALITY ASSURANCE: SIGN [signature] DATE 5-29-80
CUSTOMER QUALITY ASSURANCE: SIGN [signature] DATE 5/30/80

INSP ION

FORM QC393 (7 79)

Figure 2-3. Inspection Rejection Report No. 94579

INSPECTION REJECTION REPORT — CONTINUATION

PAGE 2 OF | PART NUMBER 1029110-108 | IRR Nº 94579

ITEM NO	SPECIFICATION	S N	B.P LOC	DISCREPANCY CHECKS	OCCURENCES	DEFECT CODE	PMR REVIEW USE	RWK	Scrap	MRB	C/A LEVEL
3.	ENG. CONFIGURATION	828		P/N 36240 FUEL CONTROL INSTALLED IN PLACE OF 23860 FUEL CONTROL (PRIOR TO GOVT. APPROVAL)	1/1	E				X	1
4	Eng. Configuration	828		P/N 34733 Hot Gas Collat Installed but not Approved Ref ECP-0642R2	1/1	F				X	1

CONTINUED DISPOSITIONS

MATERIAL REVIEW BOARD

		WRC ENGINEERING		WRC QUALITY ASSURANCE		CUSTOMER QUALITY ASSURANCE	
SIGN	DATE	SIGN Bob Phillips	DATE 5/29/80	SIGN [signature]	DATE 5-29-80	SIGN	DATE

QC 383(5 75)

INSPEC ON

Figure 2-3. Inspection Rejection Report No. 94579

DCRO-GTWC (J. Boedecker/Ext 1352/imf) 25 Mar 1980

SUBJECT: Shipping Authorization, Engine S/N 828, Contract N00019-78-C-0206

Mr. Dave Cooper
CMEP Contract Administrator
Williams Research Corporation
2280 W. Maple Road
Walled Lake, MI 48088

Dear Mr. Cooper:

You are hereby authorized to ship subject engine via air shipment on a DD Form 1149 to AEDC, Tullahoma, Tennessee.

It is noted that this engine deviates from specification and QT Test Plan requirements as documented on IRR 94579. This authorization is granted notwithstanding the deviant condition to provide for further testing of this engine.

This letter should not be construed as waiving any specification of QT requirements or any other Government rights established by the contractor. The only purpose of this letter is to acknowledge the above cited deviations and to provide shipping authorization. This authorization is granted for the sole convenience of the contractor.

This letter may be used to close the above referenced IRR per your internal requirements.

Sincerely,

JOHN A. APPLIN
Administrative Contracting Officer
DCAS-WRC Residency

cc: DCRO-GTWQ (C.C. DAVIS, Jr.)
JCM-285 (Major Rice)
ASD/YZ107 (Col. Goetz)
WRC (L. Scheen)
DCRO-GTWP (P. Janik)

Figure 2-4. Administrative Contracting Office (ACO) Letter Permitting Shipment of Engine 828/Build 6 to AEDC

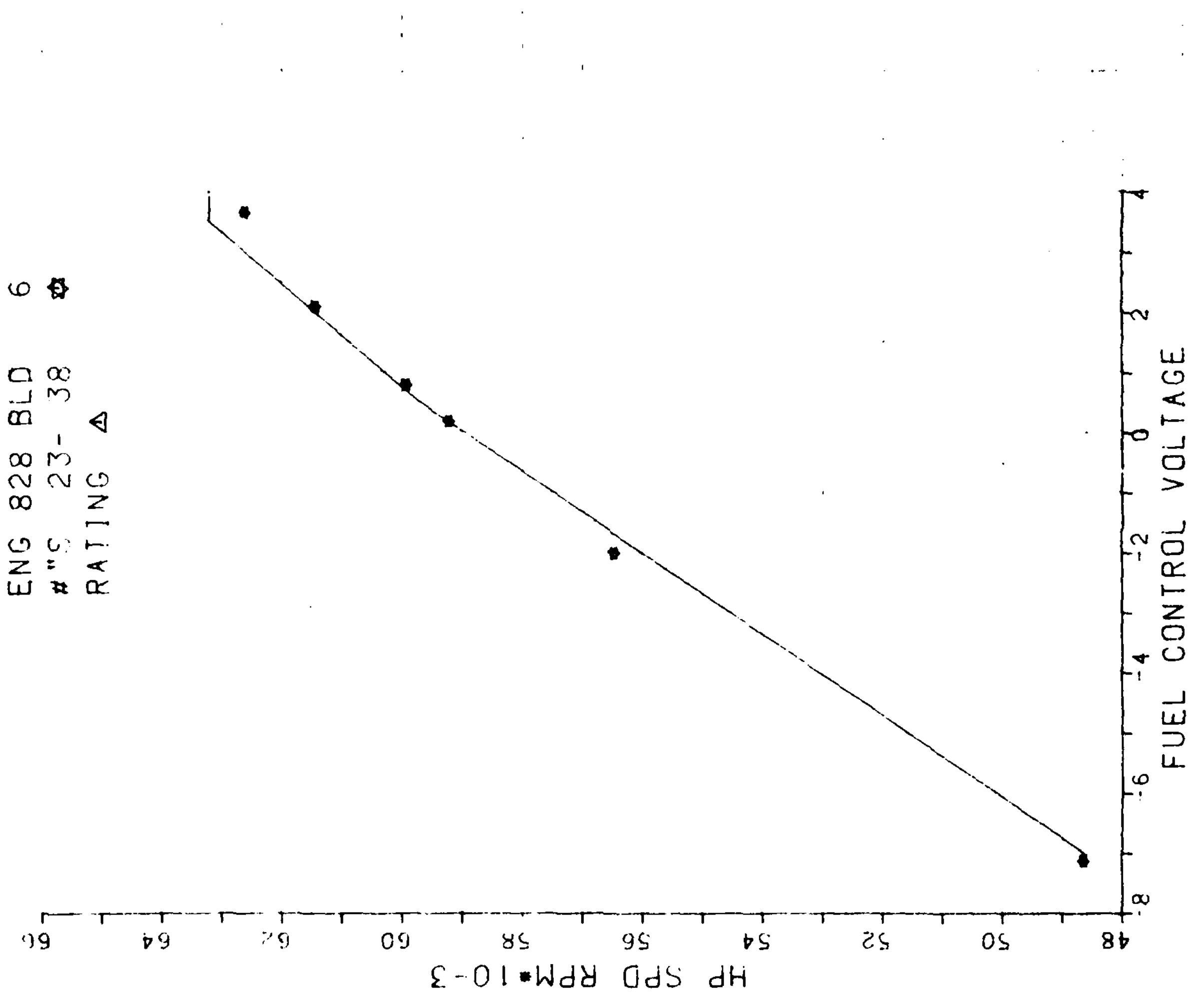


Figure 2-5. Engine 828/Build 6, HP Speed versus Fuel Control Voltage

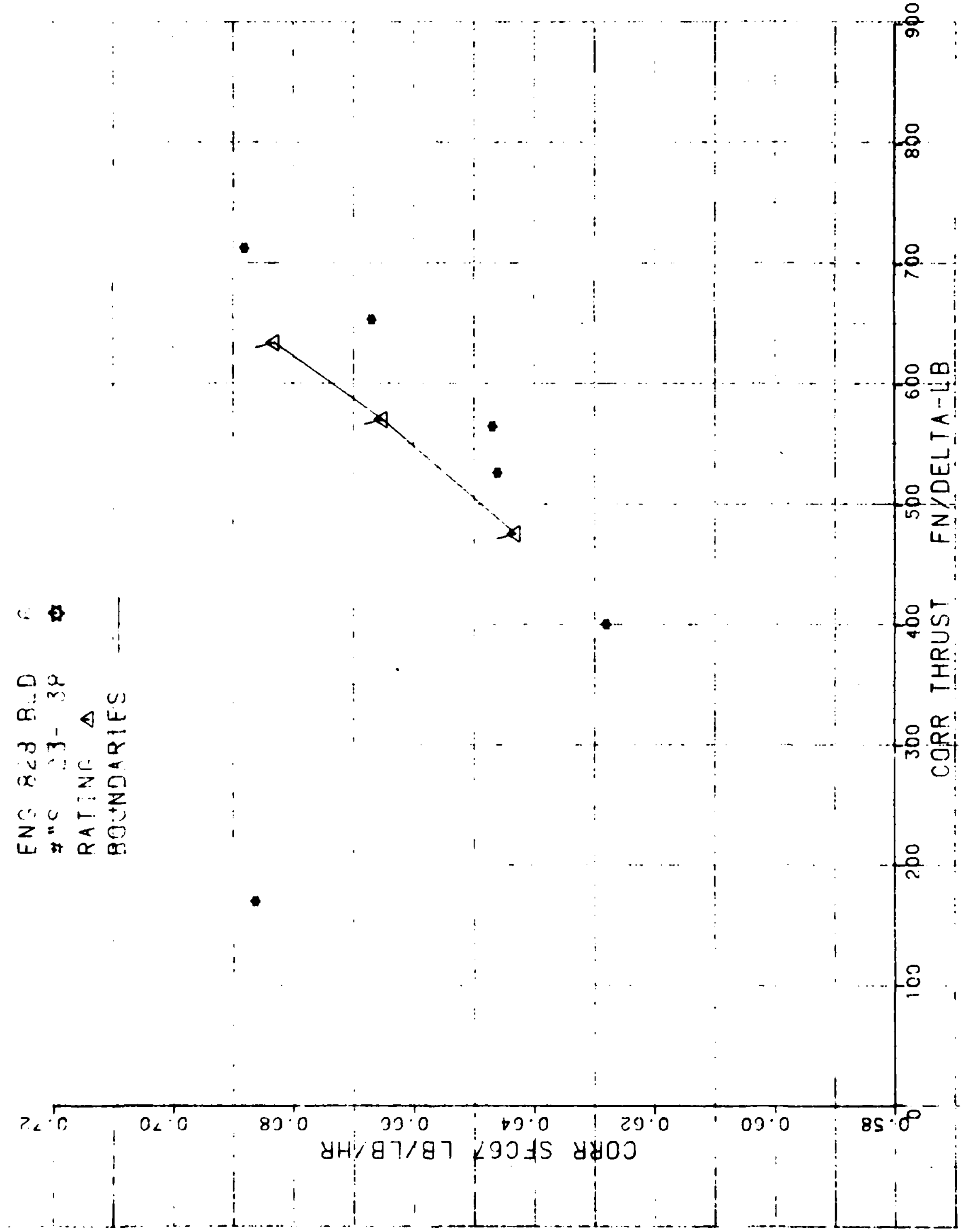


Figure 2-6. Engine 828/Build 6, Corrected Specific Fuel Consumption (SFC) versus Corrected Thrust

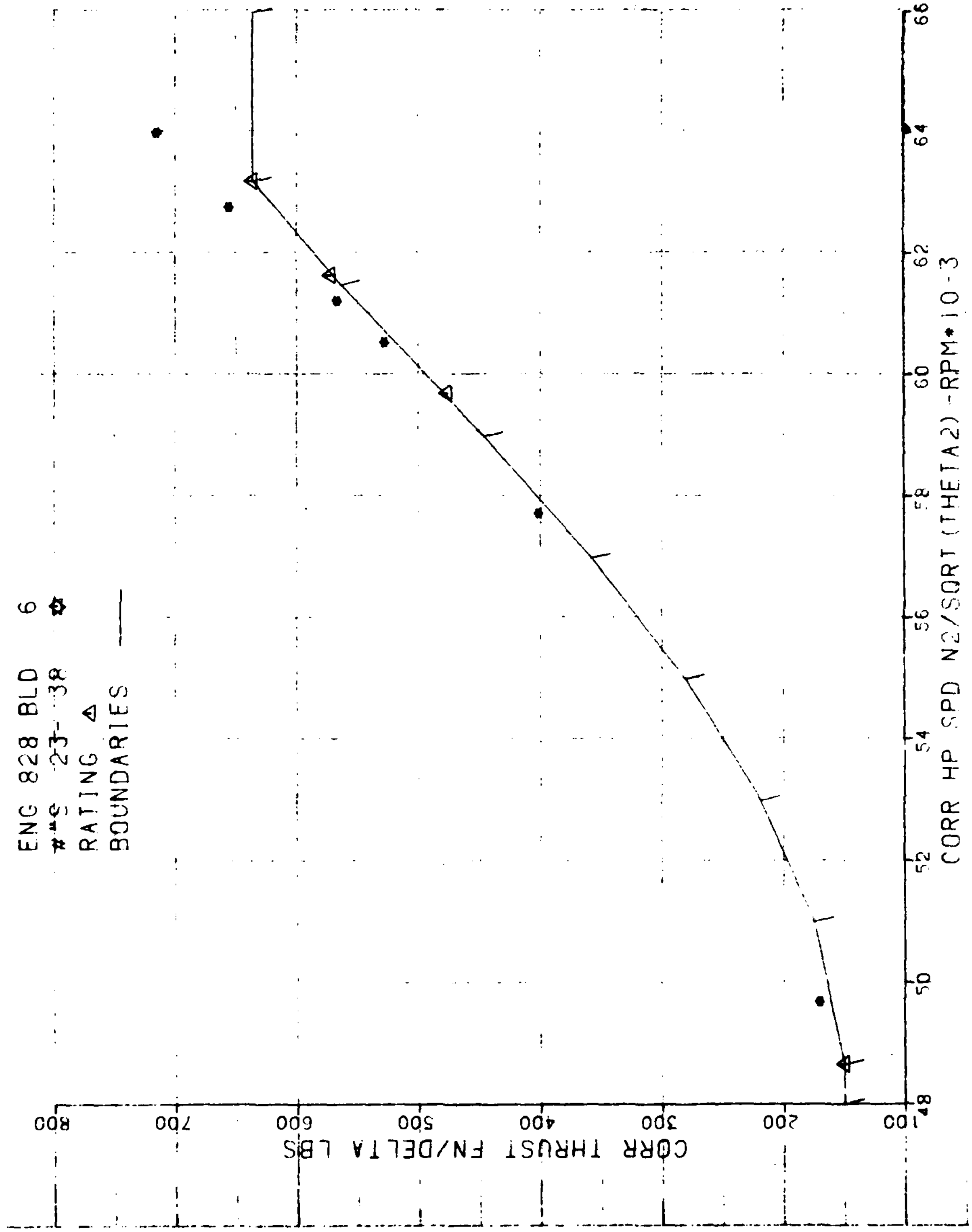


Figure 2-7. Engine 828/Build 6, Corrected Thrust versus Corrected HP Speed

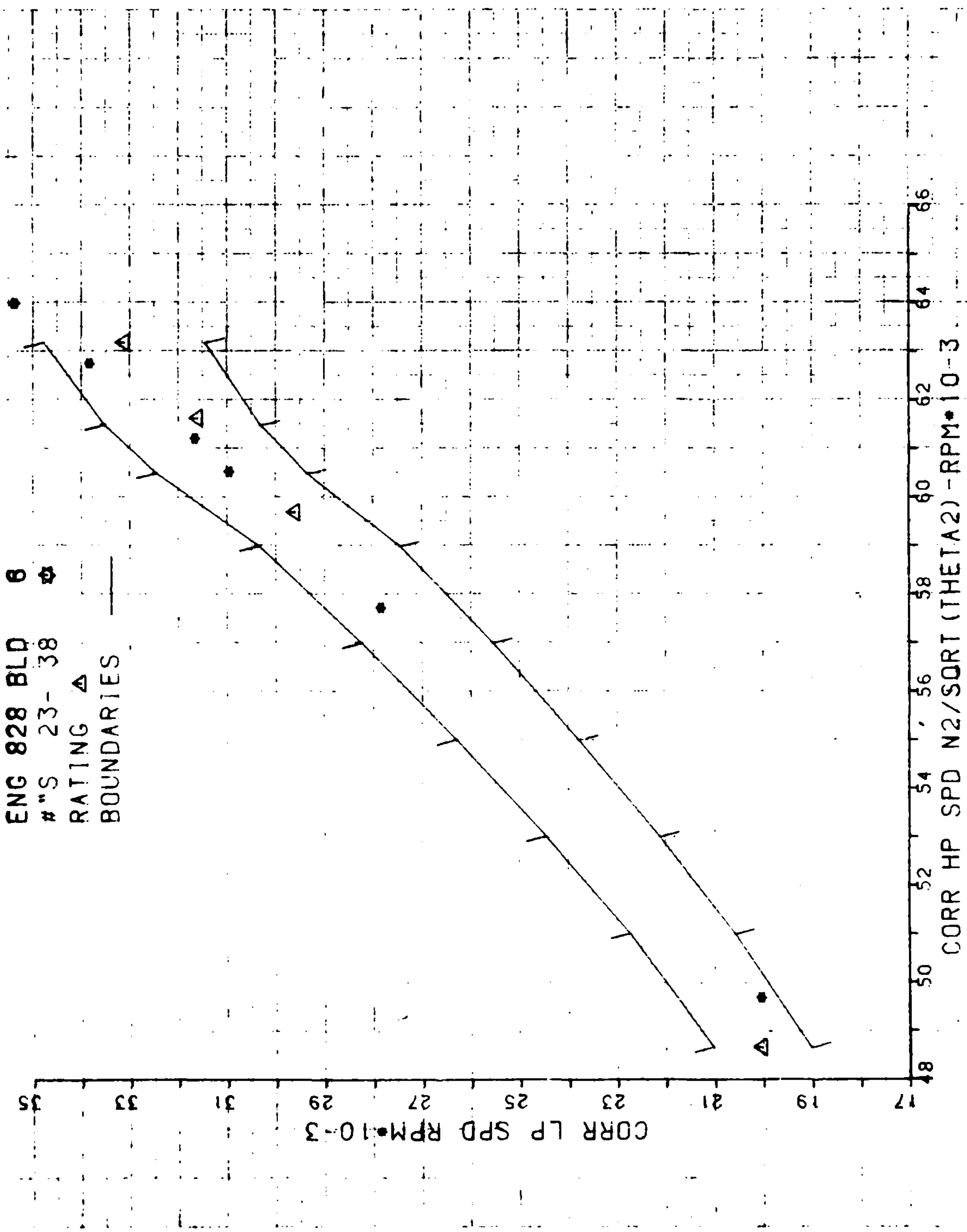


Figure 2-8. Engine 828/Build 6, Corrected LP Speed versus Corrected HP Speed

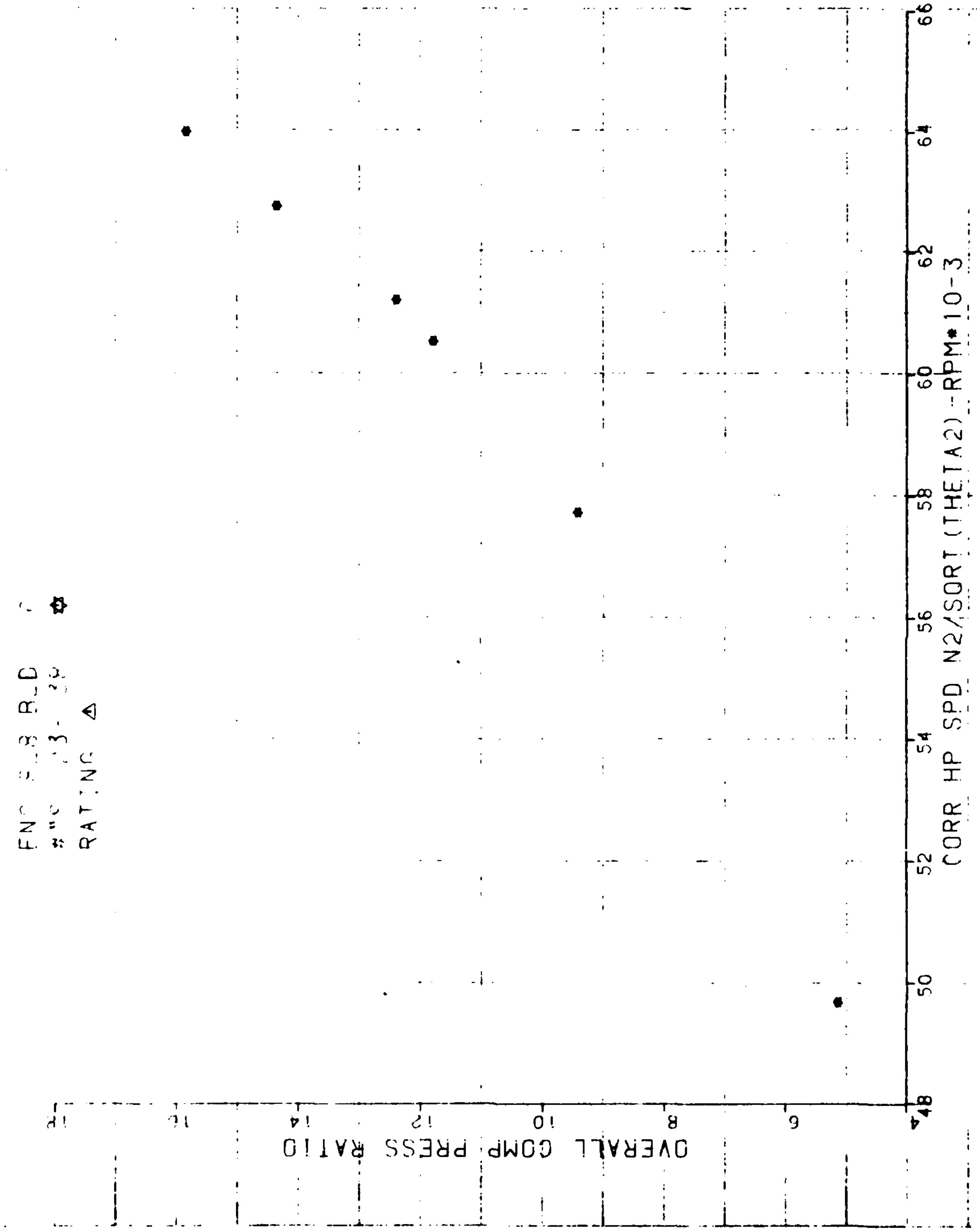


Figure 2-9. Engine 828/Build 6, Overall Compressor Pressure Ratio versus Corrected HP Speed

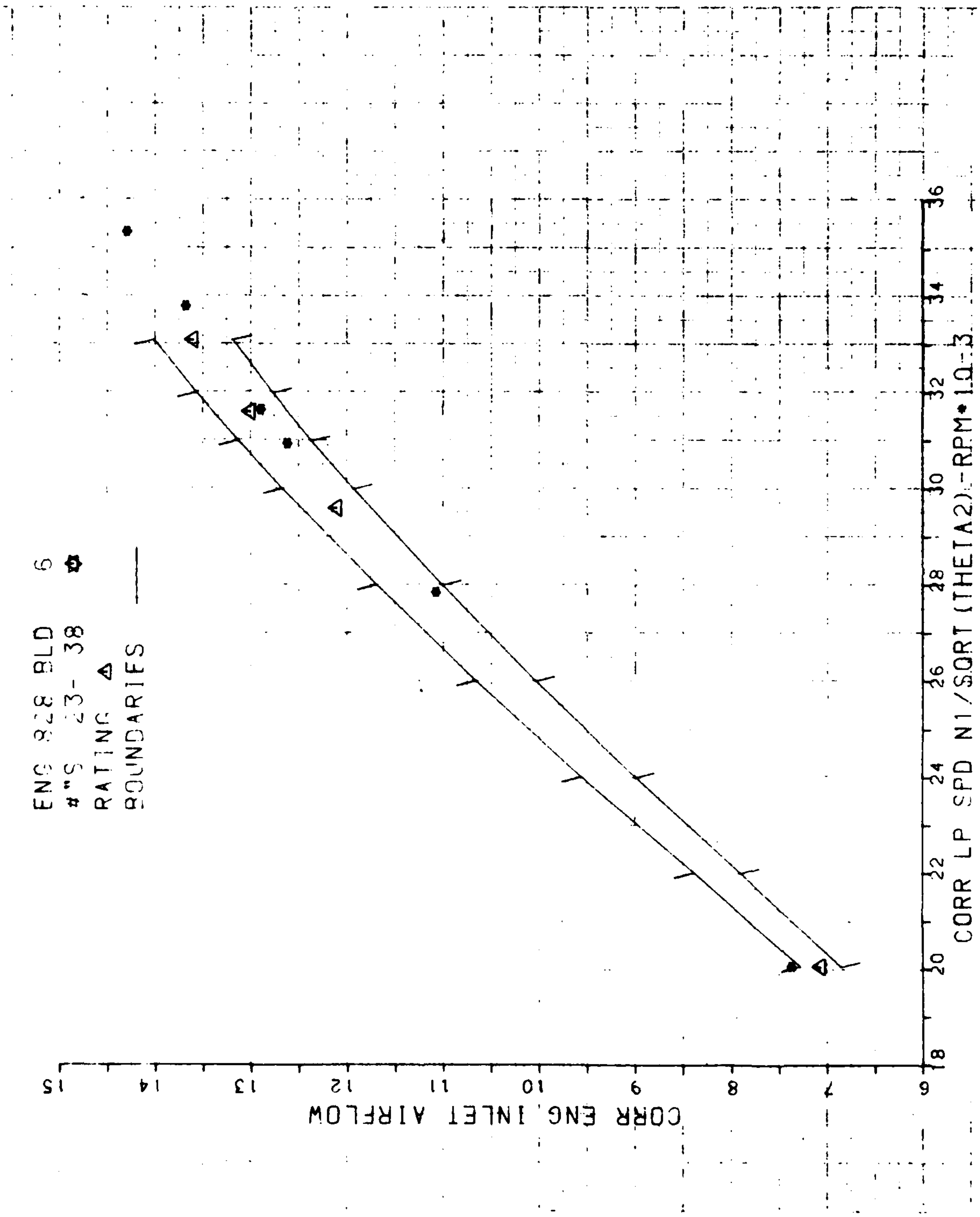


Figure 2-10. Engine 828/Build 6, Corrected Engine Inlet Airflow versus Corrected LP Speed

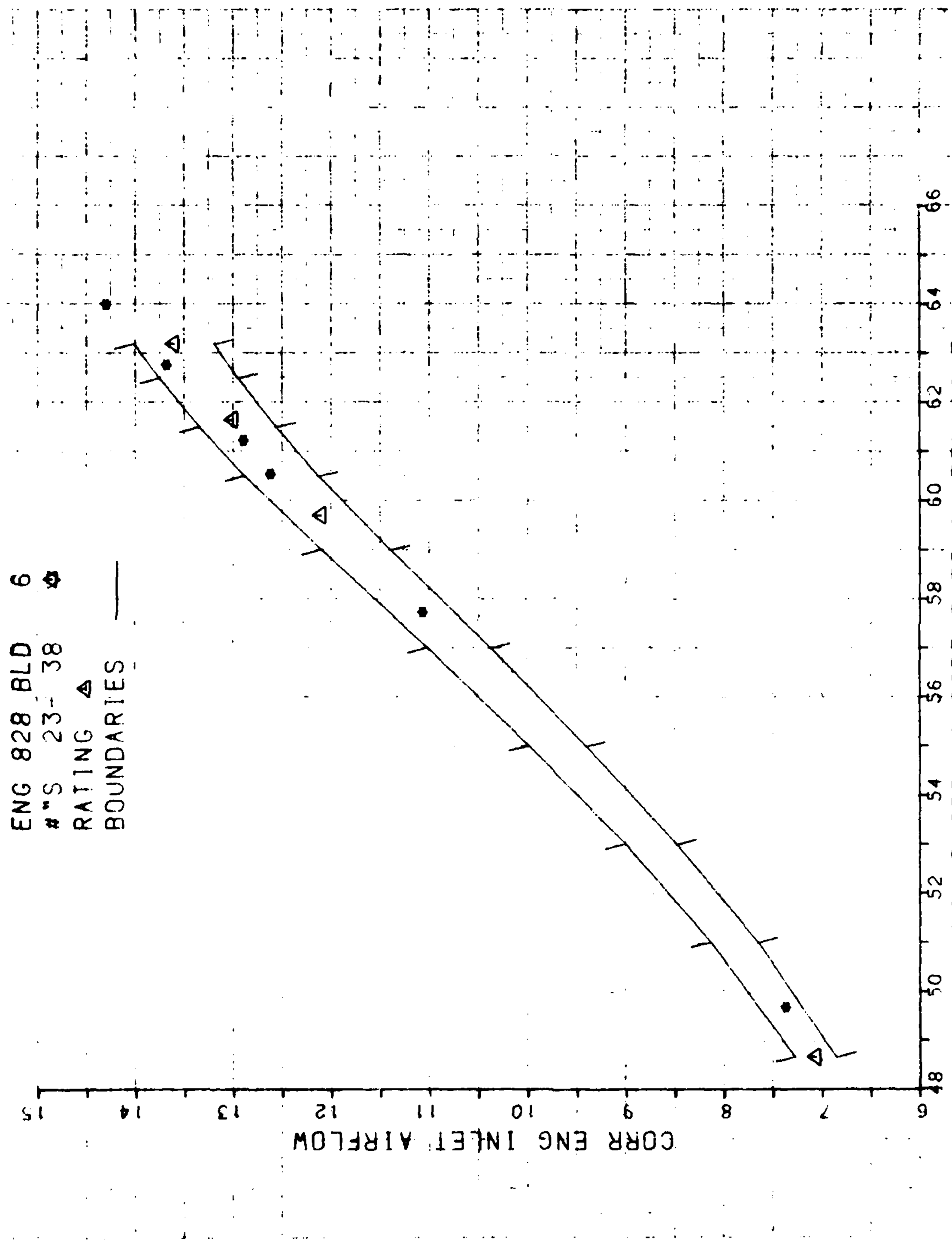


Figure 2-11. Engine 828/Build 6, Corrected Engine Inlet Airflow versus Corrected HP Speed

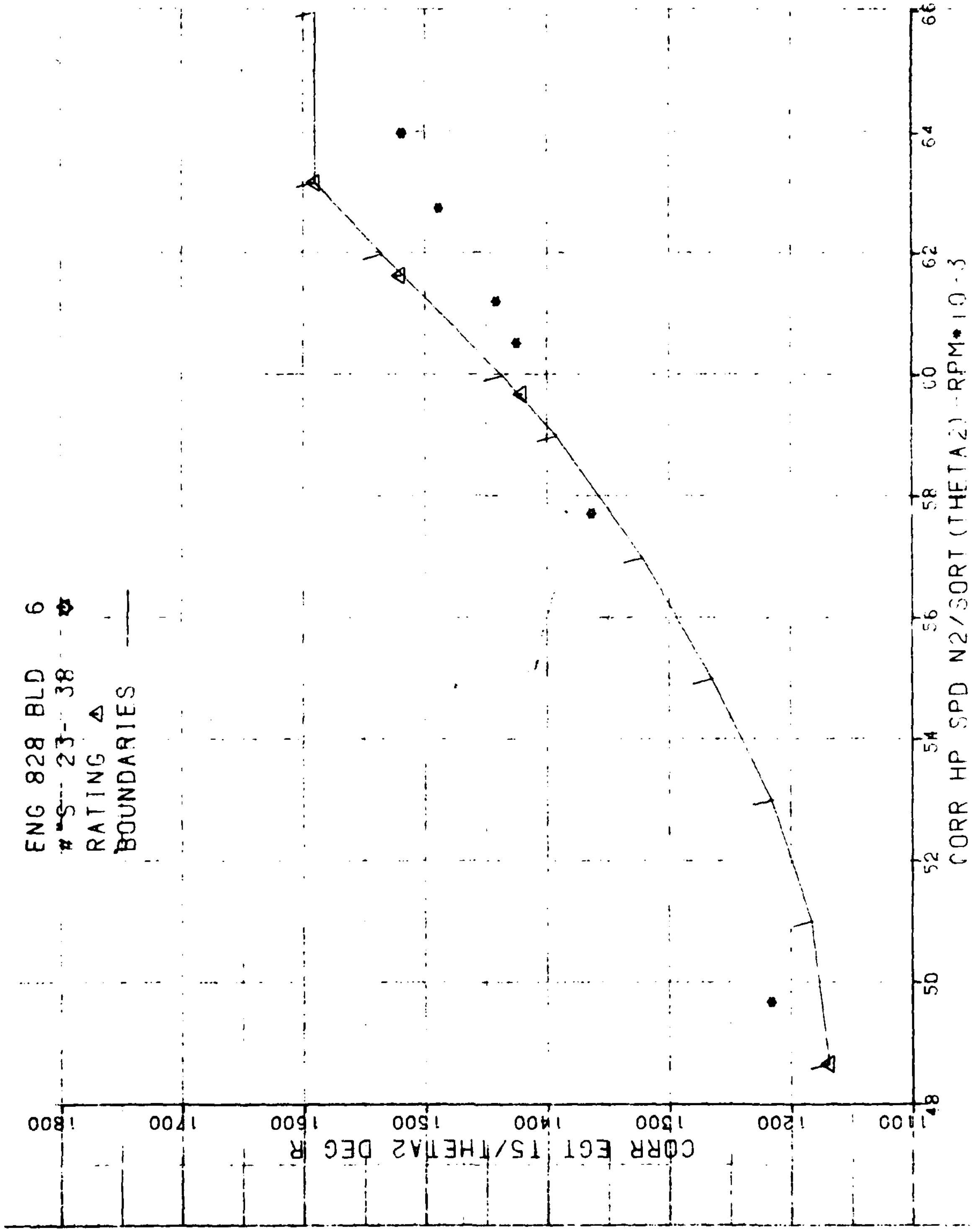


Figure 2-12. Engine 828/Build 6, Corrected Exhaust Gas Temperature (EGT) versus Corrected HP Speed

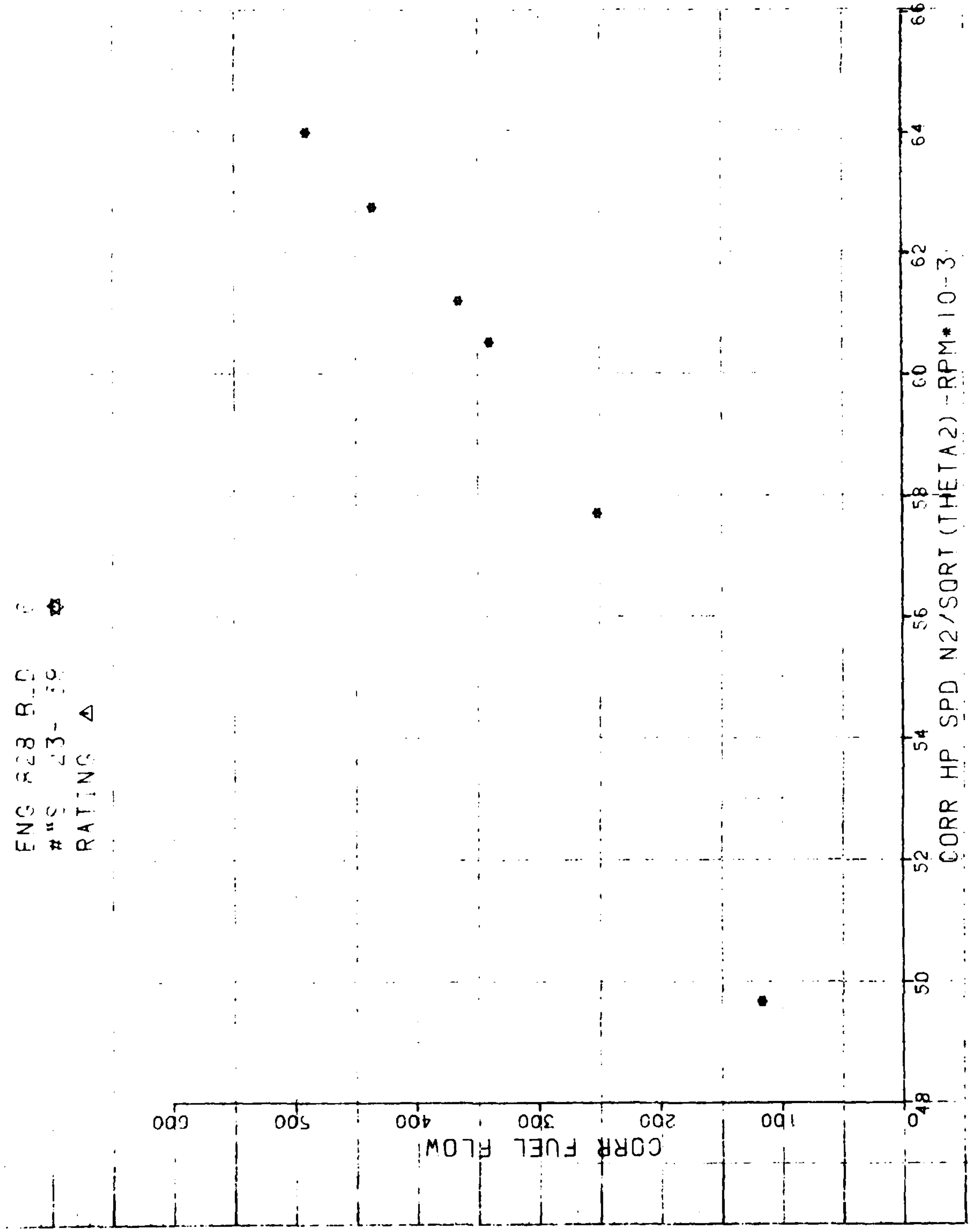


Figure 2-13. Engine 828/Build 6, Corrected Fuel Flow versus Corrected HP Speed

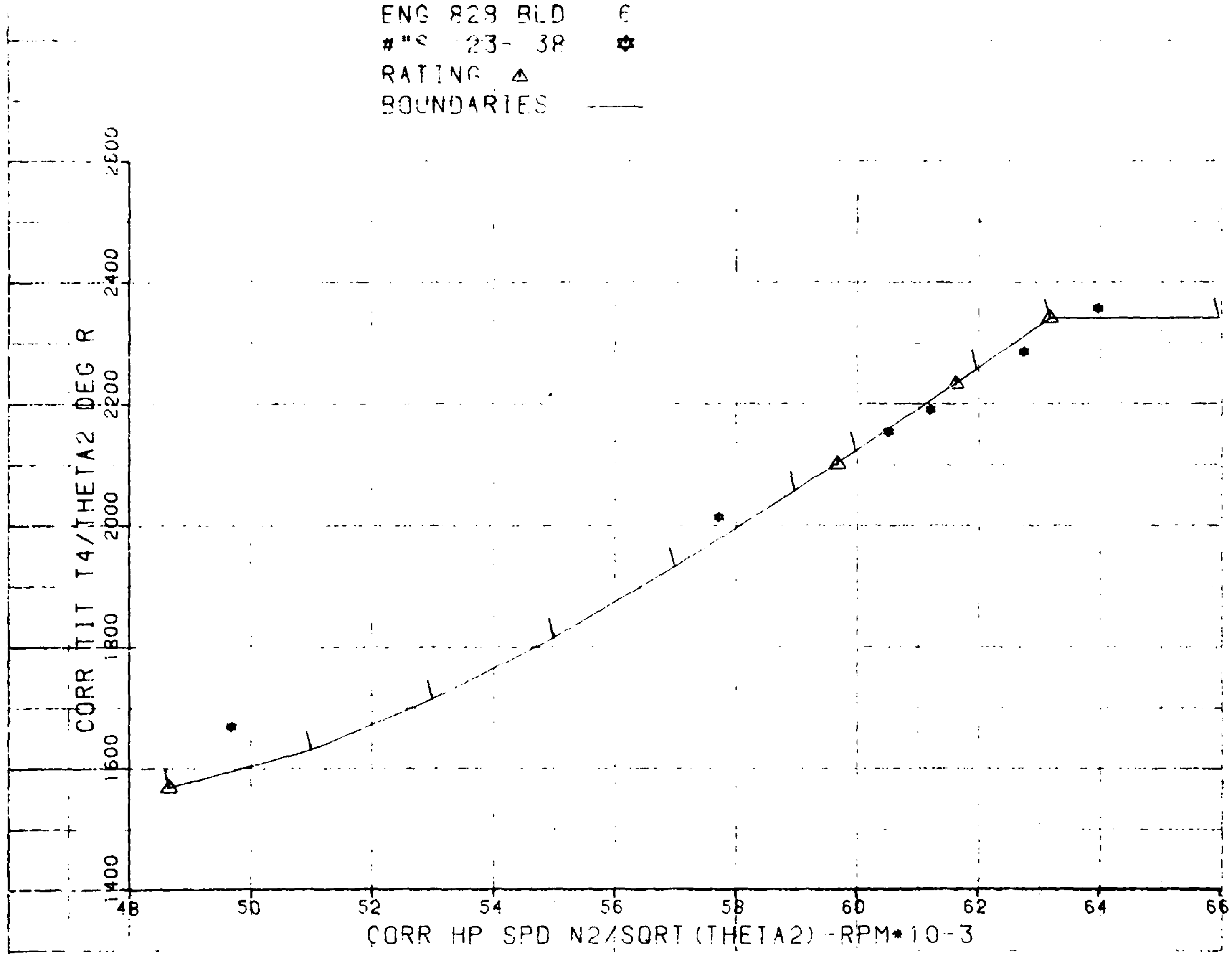


Figure 2-14. Engine 828/Build 6, Corrected Turbine Inlet Temperature (TIT) Versus Corrected HP Speed

Williams Research Corporation

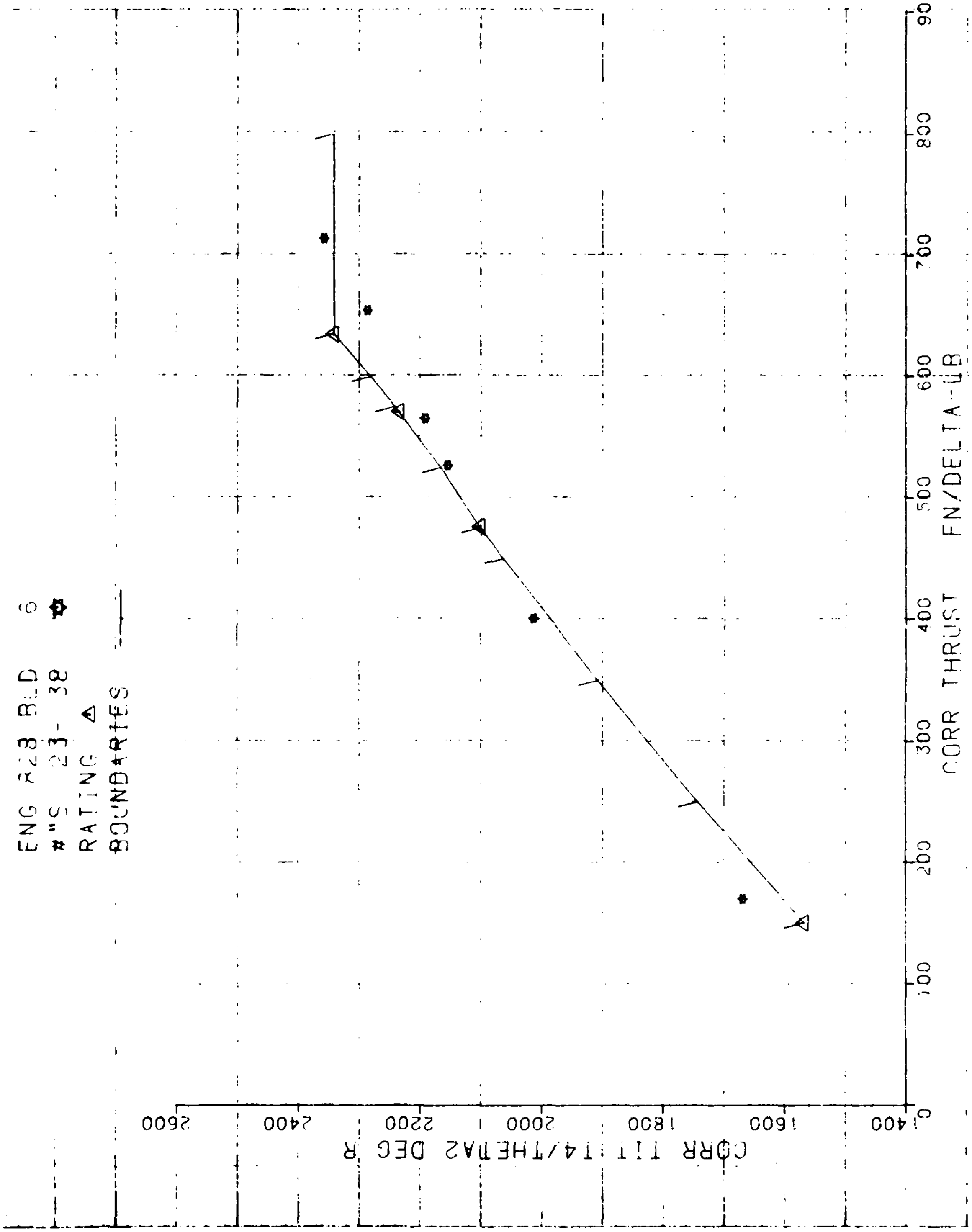


Figure 2-15. Engine 828/Build 6, Corrected Turbine Inlet Temperature (TIT) versus Corrected Thrust

F107-WR-102, 400 (WR19-A7-1) E.G.T. PROFILE

S/N 828 BLD. 5 D.P. 18

DATE 21 MAR 80 COMBUSTOR P.I.N. (OR S/N) WL-1014

T_1 35°F N_1 33898 N_2 63000

MAX EGT 1170 AVG EGT 1066 ΔT 104°F

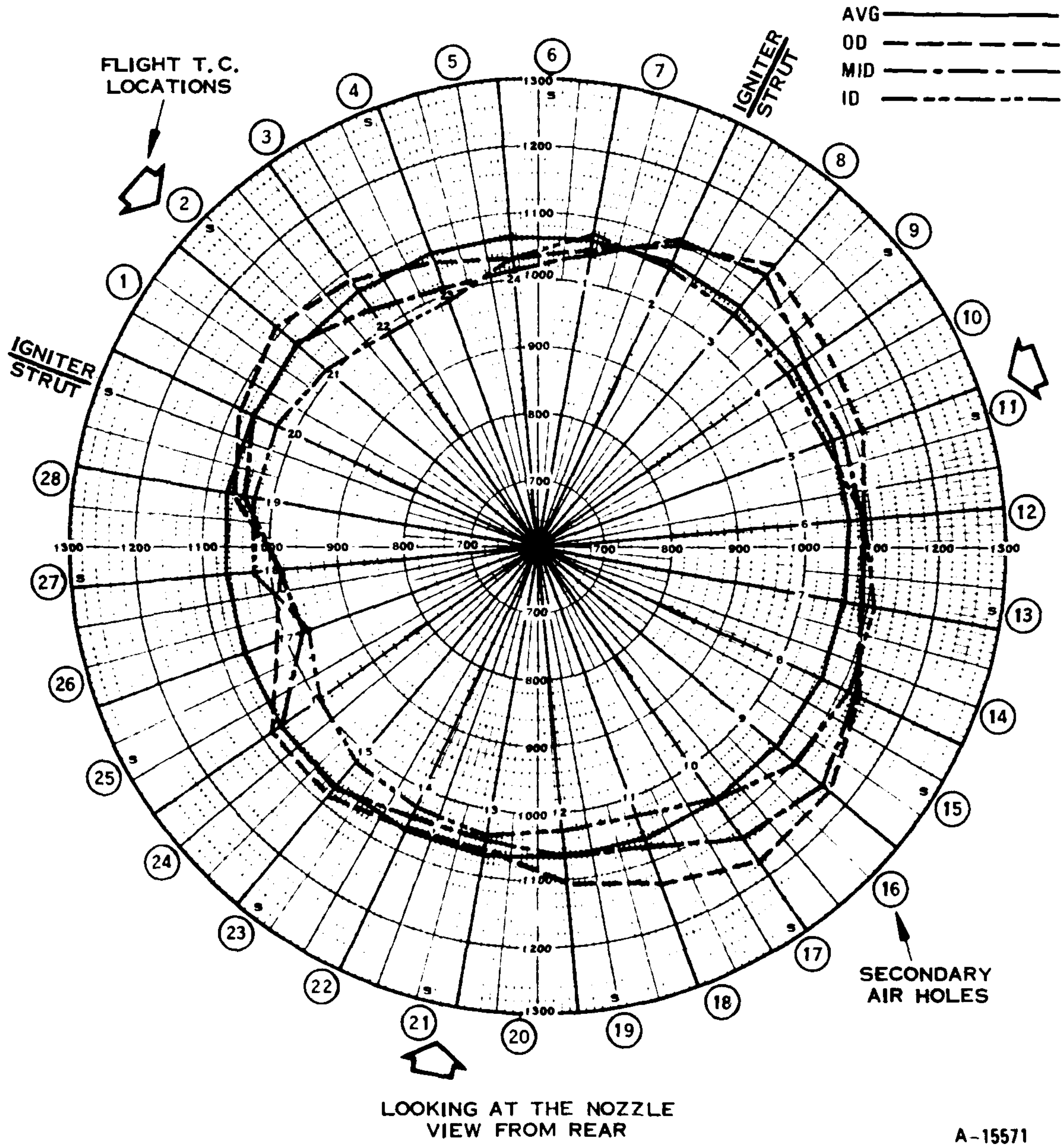


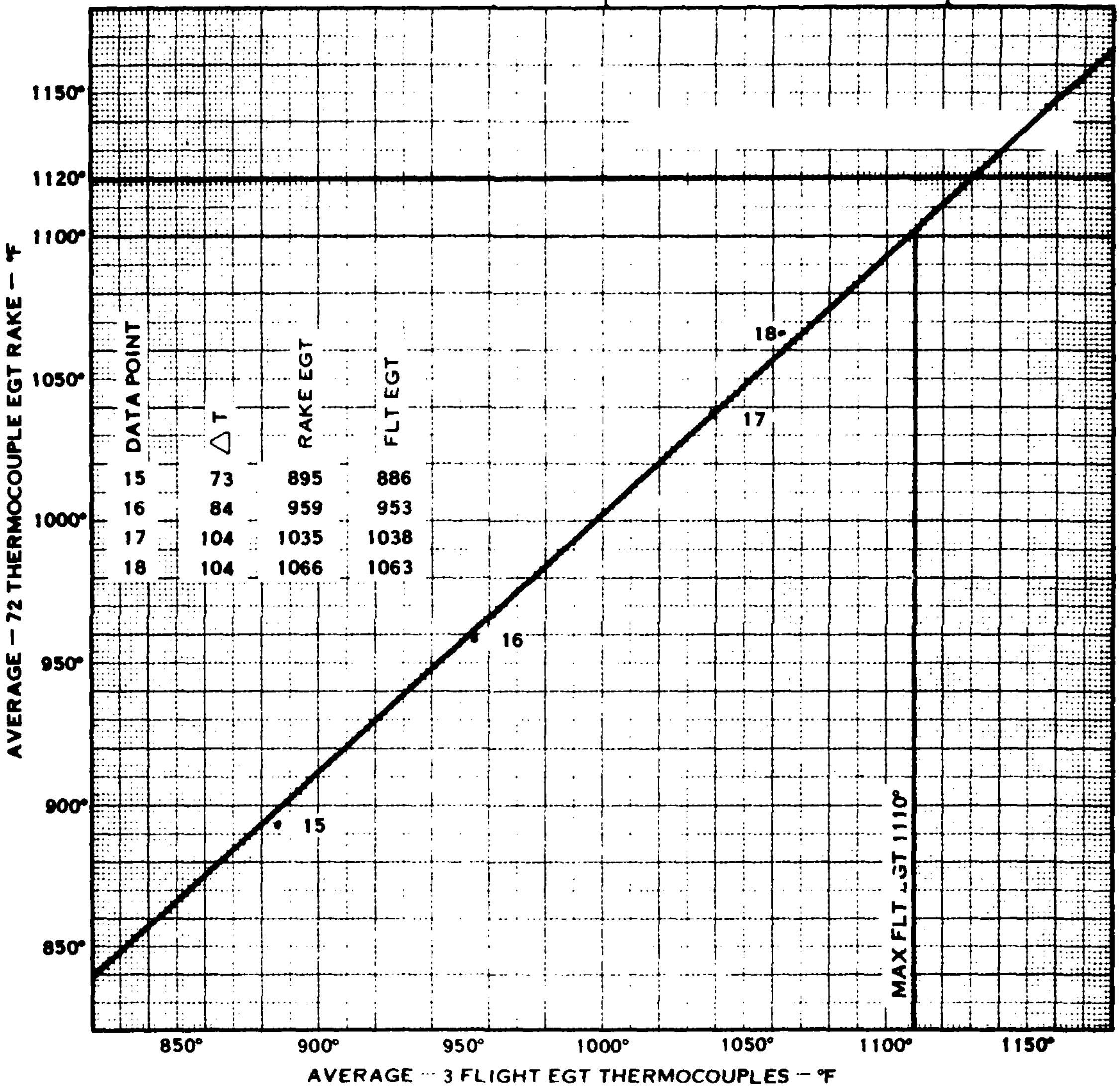
Figure 2-16. Engine 828/Build 5, Exhaust Gas Temperature (EGT) Profile

Williams Research Corporation

EGT CORRELATION CURVE

ENGINE	BUILD	CELL	TEST
828	5		

COMMENTS	ENGINEER	DATE
PENALTY RUN-B2 SLAVE HARNESS		



FOR PERFORMANCE EVALUATION									
FLT	RAKE	FLT	RAKE	FLT	RAKE	FLT	RAKE	FLT	RAKE
943	950	999	1000	1055	1050	1110	1100.	1132	1120.

8000 JUN 80

A-15570

Figure 2-17. Engine 828/Build 5, Exhaust Gas Temperature (EGT) Correlation Curve, 72 Thermocouple Rake versus 3 Flight Thermocouples

SECTION 3

QUALIFICATION TEST FACILITY RESULTS

3.1 SUMMARY

Engine 828/build 4 arrived at Bendix Aerospace Systems Division, Ann Arbor, Michigan, on 14 January, 1980, and testing was undertaken that day. The testing consisted of two components, 30 minutes of random vibrations along each of the principal engine axes and sinusoidal vibratory sweeps at constant input levels to identify resonant frequencies along the lateral and vertical engine axes, with the engine being excited for thirty minutes at each of the frequencies identified. No abnormalities occurred during this phase of the qualification testing.

Engine 828/build 4 arrived at AEDC on 21 January, 1980. Installation into Test Cell T-5 was completed on 19 February, the delay being caused by the completion of qualification testing with Engine 402. Testing was undertaken on 20 February. All required check runs and engine calibrations were completed without incident.

Shortly after undertaking the hot day mission simulation test, erratic EGT indications, coupled with a brief engine calibration, led to termination of the testing. The engine was returned to WRC, disassembled, and damaged engine hardware replaced (Ref. Report DAL 8012).

With no repetition of the engine vibration testing, the engine, now designated Engine 828/build 6, was returned to AEDC. The calibration and check runs were repeated.

Early in the second attempt to conduct the hot day mission simulation test, the fuel control unit ceased to respond to changes in PLA command voltage. A replacement fuel control unit was located, exposed to the engine vibration testing regimen, and installed on the engine. All testing scheduled at AEDC was completed on 16 April, 1980, and the engine returned to WRC.

A post-testing teardown and dimensional inspection revealed no hardware failures or signs of impending hardware failures which could have jeopardized successful mission completion.

3.2 PROCEDURES

3.2.1 Test Article Description

Engine 828/build 4 was vibration tested at Bendix Aerospace-Ann Arbor in its as-shipped configuration. Initially, the engine was installed into Test Cell T-5 at AEDC in that same configuration. Following the abortion of the first attempt to conduct the mission simulation testing, and a subsequent rebuild at WRC (ref. paragraph 2.3.2.), the engine was reinstalled into Test Cell T-5 at AEDC in its as-shipped condition. During that second phase of engine testing, the only hardware change, other than those authorized in paragraph 3.2.4.8 of the Qualification Test Plan (CMEP 91-4043G), was the replacement of the failed fuel control.

3.2.2 Test Facilities

Engine 828/build 4 and the replacement fuel control unit for build 6 were vibration tested at Bendix Aerospace-Ann Arbor, Michigan. Details on the Bendix facility are included in Appendix F of the Qualification Test Plan. Photographs of a typical F107 engine installation at the Bendix facility are displayed in Figures 3-36 through 3-38.

Engine 828/builds 4 and 6 were tested at AEDC, Tullahoma, Tennesee, in Test Cell T-5. A detailed description of the test facility at AEDC is contained in Appendix D of the Qualification Test Plan. A typical F107 engine installation in Test Cell T-5 at AEDC is shown in Figures 3-39 through 3-41.

3.2.3 Test Procedures

The vibration and mission simulation tests, as well as associated check runs, instrumentation runs, and calibrations runs, were performed in compliance with the Qualification Test Plan and Run Program QT21. Run program QT21 and its addenda are presented in Appendix B of this text.

3.3 RECORD OF TEST

3.3.1 Record of Vibration Testing at Bendix Aerospace-Ann Arbor

Engine 828/build 4 was initially shipped to Bendix Aerospace-Ann Arbor on 4 January, 1980, to conduct vibration testing for the F107-WR-400 engine in accordance with the PID Specification and the QTP. The testing proceeded without major incidents and was complet-ed on 7 January 1980. After the engine had been returned to WRC, it was discovered that no airframe generator had been mounted on the engine during the vibration testing. This omission required a repetition of the vibration testing.

Engine 828 was received at Bendix Aerospace-Ann Arbor for the second test series on 14 January 1980 and began testing on the same day. All scheduled testing was completed at ambient temperatures.

A discrepancy exists between the axis labelling conventions used by Bendix Aerospace Systems and WRC. The Bendix convention labels the longitudinal axis "X" with positive direction extending out through the engine inlet, the lateral axis "Y" with positive direction extending out to engine starboard (when viewed from aft looking forward), and the vertical axis "Z" with positive direction down. The WRC convention for the Convair engine, is dictated by triaxial accelerometer mounting position, with labelling of the longitudinal axis "X", the lateral axis "Z" and the vertical axis "Y", having positive sense in the same direction as the Bendix convention, except that the positive vertical direction is up. This discrepancy results in different labelling of vibration data obtained at Bendix Aerospace and at AEDC.

Initially, a sinusoidal vibration sweep was performed on the engine lateral (Z) axis to identify resonant frequencies. These frequencies were identified to be 77 Hz, 90 Hz and 100 Hz. The lateral axis was subjected to a vibration input at a level of 2g's for a 30-minute period at each of the above frequencies. This was followed by a one-half hour random frequency excitation on the same axis in compliance with the F107-WR-400 spectrum.

The engine orientation relative to the test apparatus was changed to allow vibration inputs on the longitudinal (X) axis of the engine. The engine was then subjected to a random frequency vibration input on the longitudinal axis for 30 minutes in compliance with the F107-WR-400 spectrum.

Engine orientation on the shake fixture was repositioned in order to align the vibration axis along the vertical (Y) axis. A sinusoidal sweep was then performed to identify the resonant frequencies. These frequencies were identified to be 13 Hz, 80 Hz and 100 Hz. The vertical axis was then subjected to a sinusoidal vibration at a level of 2g's for a 30-minute period at each of the resonant frequencies. The vibration test series was completed with a 30-minute random frequency vibration excitation on the vertical axis in compliance with the F107-WR-400 spectrum.

A presentation of the PSD curves obtained at Bendix Aerospace during the testing of this engine, as well as a chronicle of significant test events, is contained in Appendix D of this text.

The engine was returned to WRC on 16 February 1980 preparatory to shipment to AEDC for mission simulation testing.

3.3.2 Record of Testing at AEDC

Note: The initial attempt to conduct the hot and cold day mission simulation tests at AEDC was aborted on 25 February 1980 when both an increase in EGT and a marked change in engine spool speed match were noted. A subsequent teardown investigation at WRC revealed two burned first nozzle vanes. The engine was reassembled with a new fuel slinger and combustor/first nozzle assembly. The engine was then rerun through the acceptance test procedure (ATP) and reshipped to AEDC. No repetition of the environmental vibration testing was considered necessary.

3.3.2.1 Pre-Mission Simulation Testing

Engine 828 was received at AEDC, Tullahoma, Tennessee, on 25 March 1980, and directly installed in Test Cell T-5. Some facility problems occurred, but were resolved in order to permit engine testing to begin on 1 April 1980. A sea level static, standard day check run revealed minor instrumentation problems which were easily resolved. During that check run, one flight EGT thermocouple indicated a step increase to 1074°F, but no other irregularities were reported. A pre-qualification testing sea level, Mach 0.70 calibration run with bleed airflow and generator power extraction was conducted, followed by engine operation at sea level, Mach 0.65 to complete the 4 hours, 55 minutes of engine operation required prior to the final pre-mission simulation test check run (Ref. paragraph 2.7.3 of CMEP 91-4043G). Data collected during the calibration run indicated thrust 4.1 percent above and SFC 4.7 percent below the specification requirements with an average EGT of 1030°F at maximum continuous thrust. Oil consumption during this running was computed to be 0.011 gal/hr. The final pre-mission simulation test check run was conducted on 2 April. A post-run inspection revealed no fluid leakage. A starter cartridge was then installed and the engine prepared for the initiation of the hot-day mission simulation test.

3.3.2.2 Mission Simulation Testing

Figure 3-42 displays the Phase II QT hot and cold day mission simulation test format. Scheduled changes in flight conditions are related to Table 3-IV by circled numbers. Time histories of the terrain-following cycles used in these tests are presented in Figures 3-43 through 3-47.

Test Cell T-5 at AEDC is set up to control the engine throttle command voltage, simulated altitude and Mach number, and facility data acquisition system by means of several computers which are synchronized at the start of the test. One of the computer outputs is a CRT display comparing the specification inlet temperature, in 10-minute segments, with the current actual inlet temperature. This display is used to control the inlet temperature manually during the test.

Time histories of actual test cell pressure, inlet pressure and inlet temperature are shown in Figures 3-48 through 3-50 for the hot day mission simulation and in Figures 3-52 through 3-54 for the cold day mission simulation. These figures also include the specification pressures and temperatures for comparison with the recorded data. As can be seen, the computers functioned with a high degree of accuracy in controlling the two pressures representing altitude and Mach number during both the hot and cold day mission cycles. The control of inlet temperature was generally good during both tests, except as noted in paragraph 3.3.2.2.3, with some variation due to the thermal inertia of the facility plumbing, which did not allow rapid changes in temperature at the engine inlet. Although temperature variations do affect engine performance, it was not felt that the differences which were experienced affected the validity of the engine durability demonstration.

The computers controlling the mission simulation cycles did not have sufficient storage capacity for an entire five-hour test cycle. Therefore, the program was broken into five segments. After completion of each segment, the engine was manually returned to idle speed while the new program segment was entered into the computer. The engine was not shut down during these hold periods.

Time histories of the supply fuel temperature are shown in Figure 3-51 for the hot day mission simulation test and in Figure 3-55 for the cold day mission simulation test. The specification nominal fuel supply temperature is shown for reference. The fuel temperature was controlled by a semi-automatic system which required constant monitoring and operator adjustment.

3.3.2.2.1 Hot Day Mission Simulation Test. The hot day mission simulation test was undertaken on 2 April 1980. The cartridge start was hot (1230°F EGT momentarily), but successful. Data for both this cartridge start and the start conducted at the outset of the cold day mission simulation test are presented in Paragraph 3.4.3.7 of this report.

Shortly after the computer had assumed control of the engine throttle, the PLA display became unsteady, with no attendant fluctuations in either fuel flow or rotor speeds. As the test continued, one of the individually-reporting EGT thermocouples

rose to a steady 1226°F. Finally (1:02:14 into the mission), the fuel control unit ceased responding to any variations in command voltage. It was decided, in concurrence with the customer representative, to abort the test. Using a manually-controlled facility fuel system valve, the engine was shutdown, but windmilled to avoid component damage due to heat buildup and soakback. Post-shutdown electrical tests revealed internal fuel control unit resistance and current draw well in excess of the component specification. It was elected to remove the fuel control unit and replace it with a different unit.

The replacement fuel control unit was subjected to the Tomahawk environmental vibration test at Bendix Aerospace Systems-Ann Arbor on 8-9 April 1980 (Ref. Appendix D, Section IV). The removed fuel control unit was shipped to the Woodward Governor Company for analysis (Ref. Appendix F) where the cause of the failure was traced to a faulty fuel control unit subcomponent. The replacement fuel control unit was shipped to AEDC and installed on Engine 828. Preparations for an engine calibration and trim check were then made.

The replacement fuel control unit was trimmed, using both mechanical and manual techniques, to a maximum governed HP spool speed of 62,459 rpm and an engine performance calibration conducted. That calibration indicated that SFC at maximum continuous thrust had improved 0.1 percent, but SFC at the cruise rating point had increased by 1.3 percent. Maximum thrust had decreased by 2.6 percent. All of these parameters, however, still easily satisfied the specification requirements.

Following an oil and oil filter change and the installation of igniter plugs subjected to the Tomahawk environmental vibration test along with the replacement fuel control unit, the hot day mission simulation test was restarted, with a compressed air start. The hot day test was then concluded, with the most significant item of note (derived by post-test data analysis) being a disagreement between the manually-computed average of three EGT thermocouples and the electrically-averaged output of three others. The disagreement was about 50°F throughout the entire test cycle. Computed oil consumption for the entire hot day mission simulation test was 0.015 gal/hr.

3.3.2.2.2 <u>Recertification</u>. After completion of the hot day mission simulation test, the No. 1 bearing, both igniters, and the engine oil and oil filter element were replaced. The engine oil sump was drained and refilled with new MIL-L-23699 oil.

A recertification calibration run was performed at sea level, Mach 0.7, standard day conditions to verify engine function after the hardware changes. No meaningful changes in engine performance, in comparison to the engine calibration prior to the hot day

mission simulation test, were observed. During the recertification run, the individual EGT thermocouple T6-2 behaved erratically, as it had on earlier ocassions, but no contrary engine health parameters were observed.

3.3.2.2.3 Cold Day Mission Simulation Test. The cold day mission simulation test was conducted on 15 April 1980. The test was initiated with a successful cartridge start and was conducted with very few occurrences of note. Some items of interest, which apparently had little bearing upon the successful conclusion of the test, included continued disagreement (derived by post-test data analysis) between the average of the individually-reporting EGT thermocouples and the three electrically-averaged EGT thermocouple outputs (about 40°F), depletion of the facility liquid air supply which led to a loss of inlet temperature control, repeated freezing of water collected in the facility fuel filter (causing several interruptions of the test cycle for thawing) and reports of "sparks" from the engine tailpipe for which no origin could be pinpointed. At the conclusion of the test, oil consumption was computed to be 0.007 gal/hr. Some deposits were found on the magnetic drain plug. (This item is discussed in paragraph 3.5.2., Teardown Inspection Results.)

3.3.2.3 Post-Mission Simulation Testing

Prior to the post-mission simulation calibration run, the engine igniters, oil and oil filter element were changed. Some debris was found in the filter element. A three-point engine calibration at sea level, Mach 0.7, standard day conditions was conducted, with some "sparking" from the tail pipe reported shortly after the engine was started. Data analysis indicated that, compared to the "pre-test" calibration with the replacement fuel control unit, SFC had improved slightly at both maximum continuous and cruise power levels and thrust had deteriorated only 0.7 percent and was still in excess of the specification requirement. Oil consumption for the calibration run was computed to be 0.041 gal/hr with some additional debris found on the magnetic drain plug.

Total engine running time for build 6 at AEDC was 17.0 hours with 13 starts, two of them cartridge-initiated. The engine was returned to WRC on 22 April 1980.

3.4 PERFORMANCE ANALYSIS

3.4.1 Summary

Engine 828/build 6 was scheduled to complete both hot and cold day mission simulation cycles with inlet airflow distortion screen GD1 in place.

The original start for the hot day mission cycle was a successful cartridge-initiated type with a start time of 6.25 seconds (specification requirement is 6.7 seconds).

The hot day mission cycle was terminated at a point 1.04 hours into the test when the fuel control unit ceased to respond to input voltage commands. The fuel control unit was replaced with a unit which was first run through the F107-WR-400 engine environmental vibration cycle at Bendix Aerospace. A repeat performance calibration was conducted at sea level, Mach 0.70, standard day conditions after which the engine was trimmed to yield 101.5 percent of specification maximum continuous thrust. As trimmed, HP spool speed was 150 rpm lower than the initial setting at WRC. The hot day mission cycle was reinitiated with a compressed air start and completed without further incident. Engine operating temperatures remained within limits throughout the test cycle and maximum continuous thrust was measured to be 101.7 percent of the specification requirement immediately prior to completion of the cycle.

The cold day mission cycle was initiated with a successful cartridge start at 1500 feet, Mach 0.5 with an inlet temperature of -9°F. The temperature of the air surrounding the engine was estimated to be approximately -9°F at the time of the start. Engine start time was 9.3 seconds as compared to the specification requirement of 11.0 seconds.

Engine performance throughout the cold day mission cycle was satisfactory with steady-state data indicating an SFC 8.5 percent below the specification requirement. Facility problems with the liquid air supply allowed the engine inlet air temperature to rise up to a value of 15°F, 3.86 hours into the cold day cycle. At the stabilized inlet temperature maintained during the last 1.14 hours of the cycle (+15°F), maximum continuous rating thrust was measured to be 101.7 percent of the specification requirement with the fuel control unit delivering a maximum of 509 lbm/hr. Had the inlet temperature been maintained at the required level, the engine would have only developed 98.5 percent of specification thrust, since thrust output would have been restricted by the low setting of the fuel control unit maximum fuel delivery stop. The engine would have required a fuel delivery rate of 517 lbm/hr at a fuel temperature of -30°F in order to attain 100 percent of the specification required thrust. Considering the test conditions run, the fuel delivery rate from the fuel control unit should have been at least 524 lbm/hr. Refer to Section 3.4.3.4 for further discussion with respect to fuel control unit operating characteristics.

The sea level, Mach 0.70, standard day performance of the engine was above specification with a cruise rating SFC 2.4 percent below the requirement. The post-mission cycle calibration, when

compared to the pre-mission calibration, demonstrated an additional 0.2 percent improvement in SFC. By the same comparison, maximum continuous rating thrust was down 0.7 percent when observed during the post-mission cycle calibration.

The engine air bleed system delivery exceeded both flow rate and pressure requirements by 10.0 percent during the mission simulation tests.

3.4.2 Test Results

Engine 828 completed all of the scheduled testing in accordance with the requirements as listed in Run Program QT-21 (ref. Appendix B of this document). An overall performance summary is shown as Table 3-I wherein thrust and SFC are presented relative to the PID Specification Engine (Rev. C) and operating temperatures and speeds are indicated for the maximum continuous rating PLA setting of +3.65 Vdc.

Performance results from the WRC prequalification tests and the AEDC trim check calibration (sea level, static, standard day condition) are shown in Figures 3-1 through 3-5. A direct comparison of the sea level, static data from both test facilities is presented in Table 3-II. The data shown for operation at the maximum PLA setting of +3.65 Vdc represents performance with the original fuel control as trimmed at WRC.

Figures 3-6 through 3-10 demonstrate the performance recorded for the sea level, Mach 0.70, standard day calibrations with IP bleed airflow and a five-horsepower generator load. The data presented include that which was recorded during the initial performance calibration at AEDC, the recalibration after replacement of the fuel control unit (refer to paragraph 3.4.1), the recertification performance calibration and the post-mission simulation performance calibration. Table 3-III includes data extracted from these six performance curves so as to present a detailed comparison with the F107-WR-400 specification rating points at Mach 0.7.

Figure 3-11 presents the hot day mission simulation profile which includes a cartridge start at Mach 0.5. Performance data recorded during the mission cycle are presented in Figures 3-12 through 3-18. These are steady-state data recorded during fixed throttle segments. Data are shown for both the initial attempt to conduct the hot-day cycle and the second, more successful, conduction of the hot day cycle with a new fuel control unit installed.

The cold day mission profile is presented in Figure 3-19. Performance data for the cold day mission cycle are shown in Figures 3-20 through 3-26. Figures 3-54 and 3-55 show the desired and actual inlet air and fuel supply temperatures. The increase in

these temperatures at the end of the mission cycle reflects the test facility problems in supplying liquid air, which caused engine inlet air temperature to drift above the specification value required for the test.

HP governed speed is graphically presented as a function of inlet temperature in Figure 3-27. The effects of fuel supply temperature on the maximum fuel delivery rate are shown in Figure 3-28.

Engine IP air bleed system performance is presented in Figures 3-29 and 3-30.

A comparison of the engine start performance with the specification requirements is shown in Figure 3-31. The start times were taken from the hot and cold day cartridge-start time histories, shown in Figures 3-32 through 3-35.

3.4.3 Data Analysis

3.4.3.1 Sea Level, Static

Engine performance for sea level, static conditions at AEDC was better than that observed at WRC in terms of both thrust and SFC. Figure 3-1 shows SFC to be 2.3 percent lower at AEDC. As received from WRC, with the initial fuel control unit installed, HP spool speed measured at AEDC was 310 rpm lower at the maximum continuous power lever command voltage. Even with the governed HP spool speed down, thrust was measured to be 4.3 percent better than at WRC for a given speed (Figure 3-2). This increased thrust is the result of a 450-rpm increase in LP spool speed (Figure 3-3). This increase has previously been noted with other engines tested at NAPC and AEDC with little attendant change in TIT or EGT. Such is the case of this engine (Figure 3-4).

3.4.3.2 Sea Level, Mach 0.70, Standard Day

Data for this flight condition is presented in Figures 3-6 through 3-10. A detailed comparison with the performance calculated for the F107-WR-400 specification engine (Table 3-III) shows an excellent result, with cruise rating SFC 3.7 percent below the specification maximum value. The engine performance observed for this engine at Mach 0.70 is probably the best seen in the qualification test series.

The reason for the outstanding performance characteristics observed cannot be identified due to the limited instrumentation installed on the engine. The engine speed match (Figure 3-8) was up 670 rpm in comparison to that calculated for the specification engine.

Airflow (Figure 3-6 and Table 3-III) was 2.3 percent above the specification requirement but was within the 3.0 percent tolerance band allowed. The engine had an "open" (+2.0 percent) first turbine nozzle which would tend to drop the bypass ratio in comparison to the specification engine.

3.4.3.3 Hot Day Mission Simulation

The hot day mission simulation data are presented in Figures 3-12 through 3-18. Data are compared to the specification requirements, running with bleed airflow, a 5.0-horsepower generator load, and inlet airflow distortion screen GD-1 installed. The engine was cycled over the mission profile shown in Figure 3-11.

Engine performance was within limits throughout the test. Data are presented for testing with the original fuel control unit and with the replacement fuel control unit installed. The initial endurance cycle was terminated after 1.04 hours of run time when the fuel control unit ceased to respond to command voltage changes. A replacement fuel control unit was fitted to the engine and a trim check performed at the Mach 0.70, standard day condition. Trimmed HP spool speed was observed to be 150 rpm lower than had been recorded with the original fuel control unit; however, thrust was measured to still be 4.7 percent above the specification requirement at the maximum continuous PLA setting. This 150 rpm change in trimmed HP spool speed can also be seen in Figure 3-14. TIT at the maximum continuous rating (Figure 3-16) shows only minor variations throughout the hot day mission cycle. The highest calculated TIT recorded was 1820°F at a point 88 minutes into the mission.

3.4.3.4 Cold Day Mission Simulation

The cold day mission cycle was conducted according to the mission profile shown in Figure 3-19. The engine performance history is presented in Figures 3-20 through 3-26. Measured thrust (Figure 3-20) was in excess of the specification maximum. Table 3-I shows a cold day SFC 9.0 percent below the value projected for the specification engine.

The cold day mission cycle was completed successfully, the only irregularity being a facility failure to maintain inlet temperatures and fuel temperatures toward the end of the cycle. Figure 3-54 demonstrates that the facility was not able to maintain the required inlet temperature during the high speed dash at the end of the cold day cycle; rather, that portion of the cycle was run at an inlet temperature of +15°F.

Running at the above mentioned deviant temperature value, maximum continuous thrust was measured to be 1.5 percent above the specification requirement (Figure 3-20); however, the fuel control unit

was at the maximum fuel flow limit, which Figure 3-21 shows to be only 509 lbm/hr as calibrated. Had the engine been run at the required inlet temperature during the high Mach number dash segment, the low fuel delivery rate from the fuel control unit would have restricted maximum continuous thrust to a value 1.5 percent below the specification requirement. Figure 3-28 demonstrates that, as calibrated, the fuel control unit was at the 509 lbm/hr maximum fuel delivery rate at a fuel temperature of -2°F. This is a value 15 lbm/hr below the lower recommended limit at that temperature. A maximum fuel delivery rate of 517 lbm/hr would be required for this engine to produce 100 percent thrust at the required inlet temperature.

The F107 engine fuel control units are adjusted to a maximum fuel delivery rate somewhat lower than the specification engine fuel delivery limit of 550 lbm/hr. That procedure has been established because the fuel control unit is adjusted with calibration fluid at room temperature conditions. Cold fuel and high density fuels both tend to raise the maximum fuel flow limit. The fuel flow limit is established and must be maintained in order to protect the engine against overpressurization when operating at cold day inlet conditions.

In Figure 3-28 it can be seen that Engine 828 at cold day conditions required 517 lbm/hr of fuel to attain maximum thrust. The pre-test calibration of fuel control unit S/N 1443454 (a replacement unit installed on the engine at AEDC, Ref. 3.3.2.2.1) demonstrated a maximum fuel delivery rate of 513.9 lbm/hr with the calibration fluid at 60°F. That value is slightly below the acceptance band. The post-test calibration of that fuel control unit demonstrated a maximum fuel delivery rate of 517.3 lbm/hr with 60°F calibration fluid. Those flow rates represent the individual calibration of fuel control unit S/N 1443454 and are not representative of all F107 engine fuel control units.

Data for Engine 828, recorded late in the cold day mission cycle with both the engine and the fuel control unit heated up as a result of 4.8 hours of operation (Figure 3-28), indicates that with fuel temperature at 60°F, the fuel delivery rate at maximum power would have been 502 lbm/hr. This represents a reduction of 11.9 lbm/hr when compared to the fuel control unit pre-test calibration. It is evident that heat soaking and thermal expansion have acted to depress the fuel delivery rate from the fuel control unit even though cold fuel is being supplied to the control.

Total fuel temperature range calibrations of a cold F107 engine fuel control unit with a JP-9 fuel supply have demonstrated that a cold fuel control, when set to the lower maximum fuel delivery limit, will deliver 550 lbm/hr when supplied with -65°F fuel. If that same fuel control unit calibration flow rate was to be

raised 5 lbm/hr with 60°F calibration fluid, data extrapolation would indicate that the cold fuel control unit would deliver 555 lbm/hr with the fuel supply temperature at -65°F. Note, however that the calibration flow rate being discussed is at or near the lower end of the specification flow rate tolerance band with 60°F calibration fluid. In a worst-case situation, with maximum fuel delivery at the upper tolerance limit, a fuel delivery of 570 lbm/hr would be possible with a cold fuel control unit and a -65°F fuel supply temperature. That high of a fuel delivery rate would be unacceptable in that it could over-pressure the engine.

3.4.3.5 Post-Mission Calibration at Mach 0.7, Standard Day Condition

The pre- and post- mission simulation test calibration comparison is presented in the performance summary (Table 3-I). Performance changes were minimal with the SFC deteriorating by less than 0.5 percent. Maximum continuous HP spool speed had decreased by only 50 rpm which yielded a 0.7 percent loss in measured thrust. The post-test calibration demonstrated that the engine still met all performance requirements.

3.4.3.6 Fuel Control Unit Performance

The engine fuel control unit maintained governed HP spool speed within the specification limits at all times. Changes in governed HP spool speed as a function of inlet temperature are shown in Figure 3-27. The engine was trimmed at WRC to an HP spool speed of 62,610 rpm at an inlet temperature of 36°F. During the initial Mach 0.70 performance calibration at AEDC the engine ran at an HP spool speed of 62,550 rpm with a TIT of 1785°F. A slight drop in maximum governed HP spool speed, to 62,400 rpm, was noted during the hot day mission cycle but the engine still produced thrust in excess of the specification requirement.

The fuel control unit was replaced after failing to respond to input voltage variations during the hot day cycle. The replacement fuel control unit was trimmed 150 rpm lower than the previous unit for Mach 0.70, standard day conditions. Note that with the replacement fuel control unit installed, the engine once again showed a drop in governed HP spool speed during the hot day cycle. The fact that the engine demonstrated a loss in governed speed with two separate fuel control units installed suggests that the phenomenon is more a characteristic of the engine than of the fuel control unit.

3.4.3.7 IP Air Bleed System Performance

The air bleed system on Engine 828 was capable of delivering the required airflow and pressure at all conditions tested. Test

results are presented in figures 3-29 and 3-30 which show the observed data for engine 828 in comparison to the F107-WR-400 specification engine. The better-than-specification results observed on this engine are due to the high LP spool speed which is shown to be 700 rpm over that calculated for the specification engine at any given speed match.

3.4.3.8 Start Analysis

Engine 828 completed two successful cartridge starts to initiate the hot and cold day mission simulation tests. The start time history traces for these two starts are shown in Figures 3-32 through 3-35. A comparison with the F107-WR-400 specification start requirements is shown in Figure 3-31. The test cell temperature around the engine was not measured on the cold day start but with the 45 minutes required to condition the inlet duct temperature to the required -9°F, it was felt that the cell ambient temperature was approaching -9°F immediately prior to the start attempt.

3.4.3.9 Conclusion

Engine 828 demonstrated compliance with the specification performance requirements for the F107-WR-400 engine. The maximum continuous rating thrust exceeded the specification requirement except where restricted by the low maximum fuel stop setting in cold climates. A low maximum fuel delivery rate has been experienced on other qualification engines and it is emphasized that the fuel control units should not be set up to deliver less than 540 lbm/hr at a fuel temperature of -65°F. For the F107-WR-400 engine, Figure 3-28 shows that fuel delivery should not be less than 528 lbm/hr with RJ-4 fuel at -15°F.

3.5 MECHANICAL ANALYSIS

3.5.1 Teardown Inspection

The post-mission simulation test, dirty and clean teardown inspections indicated that no engine hardware had failed or was in danger of failure. Minor indications of light seal and shroud rubs were present and were considered normal for an engine having completed the run program accomplished with Engine 828/build 6.

There were two items of significance noted during the teardown inspection. The first item was that one of the 13 balls in one of the accessory drive bearings had been reduced in diameter as shown in Figure 3-56. The other 12 balls measured normal and little or no distress was apparent in the bearing that contained the small ball. The other bearing of the pair appeared to have no damage and measurements appeared normal. No accurate estimate

of remaining service life is possible; however, there were no signs of progressive failure present.

The second significant item was a greater than normal amount of foreign material present in the oil reservoir. Chemical analysis of the particles indicated that 440C stainless steel, bronze, aluminum, and 300 series stainless steel comprised the majority of the material observed. The particles were most likely carried by scavenge oil flow into the reservoir where they were separated out of the low velocity oil stream. Filtering in the oil supply system would have prevented any of the particles from being carried to the oil jets. There was no evidence of excessive contamination noted in the oil filter and the oil system appeared to have operated normally throughout the test program.

3.5.2 Engine Operating Characteristics

3.5.2.1 Oil Sample Analysis Data

The oil sample analysis data presented in Table 3-V was derived from laboratory reports provided by AEDC (ref. Appendix G of this text) and is presented for information purposes only.

3.5.2.2 Oil and Bearing Temperature Data

The oil and bearing temperatures and oil pressures recorded during the testing at AEDC are compiled in Table 3-VII. No unusual trends can be observed from this information. Results of engine oil consumption tests are presented in Table 3-VI.

3.5.2.3 Engine Vibration Data

Engine vibration levels recorded during the testing at AEDC are presented in Table 3-VIII. No unusual indications or trends can be observed from this data.

3.5.2.4 Fuel Control System

The results of the pre- and post- engine test measurements on the fuel control unit, the fuel shutoff valve and the fuel control inlet air temperature sensor are shown in Appendix E of this text. The fuel control unit represented in these tests is the unit installed at AEDC (S/N 1443454) to replace the unit originally installed at WRC.

3.5.2.2 Oil and Bearing Temperature Data

The oil and bearing temperatures and oil pressures recorded during the testing at AEDC are compiled in Table 3-VII. No unusual trends can be observed from this information. Results of engine oil consumption tests are presented in Table 3-VI.

3.5.2.3 Engine Vibration Data

Engine vibration levels recorded during the testing at AEDC are presented in Table 3-VIII. No unusual indications or trends can be observed from this data.

3.5.2.4 Fuel Control System

The results of the pre- and post- engine test measurements on the fuel control unit, the fuel shutoff valve and the fuel control inlet air temperature sensor are shown in Appendix E of this text. The fuel control unit represented in these tests is the unit installed at AEDC (S/N 1443454) to replace the unit originally installed at WRC.

TABLE 3-I. ENGINE 828/BUILD 6, PERFORMANCE SUMMARY (BLEED AIRFLOW AND 5.0 HORSEPOWER GENERATOR LOAD)

TEST SITE	TEST CONDITION	RATING	ΔSFC (%)	MAX THRUST (%)	MAX TIT (°F)	MAX EGT (°F)	MAX N_2 RPM
WRC	SL Static Standard Day	Maximum Continuous 90% Maximum Continuous 75% Maximum Continuous	-3.4 -2.6 -1.6	100.9	1805	1020	62610
AEDC	SL Static Standard Day	Maximum Continuous 90% Maximum Continuous 75% Maximum Continuous	-5.7 -5.7 -4.5	102.3	1788	1009	62300
AEDC	SL Mach 0.7 Standard Day (Initial Cali- bration)	Maximum Continuous 90% Maximum Continuous 75% Maximum Continuous Cruise	-4.7 -4.2 -3.8 -3.7	104.1	1785	1030	62550
AEDC	SL Mach 0.7 Standard Day (Replacement Fuel Control)	Maximum Continuous 90% Maximum Continuous 75% Maximum Continuous Cruise	-4.8 -4.2 -3.0 -2.4	101.5	1782	1030	62400
AEDC	SL Mach 0.7 Standard Day (Post Mission Simulation)	Maximum Continuous 90% Maximum Continuous 75% Maximum Continuous Cruise	-4.9 -3.4 -2.5 -2.6	100.8	1790	1035	62350
AEDC	Hot Day Mission, 600 Feet (Dash)	Maximum Continuous	-6.6	101.7	1815	1070	62150
AEDC	Cold Day Mission, 600 Feet (Dash)	Maximum Continuous	-9.0	98.5	1626	898	59250

TABLE 3-II. ENGINE 828/BUILD 6, PERFORMANCE COMPARISON, WRC TO AEDC. (SEA LEVEL, STATIC, STANDARD DAY)[1]

		WRC Actuator	AEDC
I.	At $N_2/\sqrt{\theta}$ = N_2 Test at +3.65 VDC to Fuel Control		
	Thrust Fn/δ (100% FM min - INDICATE % FM) [2]	100.8	102.3
	HP Speed $N_2/\sqrt{\theta}$ (63200 rpm max)	62,610	62,300
	LP Speed $N_1/\sqrt{\theta}$ (34755 rpm max)	33,400	33,390
	EGT EGT/θ (1130°F max)	1020	1009
	TIT/θ (1925°F max)	1805	1788
II.	At Fn/δ = Fm		
	EGT EGT/θ (1130°F max)	1010	1035
	SFC $SFC/\theta^{.67}$ (100% SFCM max - INDICATE % SFCM)[3]	-3.4	-5.7
	Airflow $W\sqrt{\theta}/\delta$ (14.0 lbm/sec max) (13.19 lbm/sec min)	13.50	13.60
	HP Speed $N_2/\sqrt{\theta}$ (63200 rpm max)	62,400	62,050
	LP Speed $N_1/\sqrt{\theta}$ (34755 rpm max) (31445 rpm min)	33,200	33,050
III.	At Fn/δ = 90% Fm		
	EGT EGT/θ (1060°F max)	935	990
	SFC $SFC/\theta^{.67}$ (97.4% SFCM max - INDICATE % SFCM)	-2.7	-5.7
	Airflow $W\sqrt{\theta}/\delta$ (13.39 lbm/sec max) (12.61 lbm/sec min)	12.95	13.0
	HP Speed $N_2/\sqrt{\theta}$ (62883 rpm max) (60417 rpm min)	61,300	60,900
	LP Speed $N_1/\sqrt{\theta}$ (33180 rpm max) (30020 rpm min)	31,800	31,700
IV.	At Fn/δ = 75% Fm		
	EGT EGT/θ (960°F max)	940	935
	SFC $SFC/\theta^{.67}$ (94.1% SFCM max - INDICATE % SFCM)	-1.6	-4.5
	Airflow $W/\sqrt{\theta}/\delta$ (12.46 lbm/sec max) (11.74 lbm/sec min)	12.00	12.05
	HP Speed $N_2/\sqrt{\theta}$ (60894 rpm max) (58530 rpm min)	59,500	59,050
	LP Speed $N_1/\sqrt{\theta}$ (31080 rpm max) (28120 rpm min)	29,800	29,600

[1] WRC data corrected to sea level, static, standard day conditions.

[2] FM is minimum thrust at the maximum continuous rating at sea level static as specified in Table 1 of PID Spec 24235WR9501A SCN 010 dated 17 October 1978.

[3] SFCM is maximum SFC at condition 1.

TABLE 3-III. ENGINE 828/BUILD 6, COMPARISON OF PERFORMANCE DATA WITH THE F107-WR-400 SPECIFICATION REQUIREMENT (SEA LEVEL, MACH 0.70, STANDARD DAY WITH 0.15 PERCENT BLEED AIRFLOW AND 5.0 HORSEPOWER GENERATOR LOAD)

RATING	PARAMETER	SPECIFICATION	ENGINE 828	DIFFERENCE
Maximum PLA (+ 3.65 Vdc)	Thrust (lbf)	464.0	482.0	+4.1%
	SFC (lbm/lbf-hr)	1.02	0.974	-4.7%
	N_1 (rpm)	31,910	32,220	+310 rpm
	N_2 (rpm)	62,910	62,550	-360 rpm
	TIT (°F)	1,869	1,785	-84°F
	EGT (°F)	1,127	1,030	-97°F
	Airflow (lbm/sec)	16.72	17.1	+2.3%
90% Maximum Continuous Thrust	Thrust	418.0	418.0	0
	SFC	1.024	0.982	-4.2
	N_1	30,900	31,700	-800
	N_2	62,000	61,180	-820
	TIT	1,800	1,760	-40
	EGT	1,087	1,012	-75
75% Maximum Continuous Thrust Thrust	Thrust	348.0	348.0	0
	SFC	1.04	1.002	-3.8
	TIT	1,694	1,620	-74
	EGT	1,015	935	-80
68.6% Maximum Continuous Thrust (Cruise Rating)	Thrust	318.0	318.0	0
	SFC	1.051	1.013	-3.7
	TIT	1,647	1,580	-67
	EGT	985	910	-75

Engine trim at WRC 62,610 rpm, thrust 641 lb (+0.9%) at maximum continuous with initial fuel control as installed at WRC.

TABLE 3-IV. HOT AND COLD DAY MISSION SIMLATION, SCHEDULED CHANGES IN FLIGHT CONDITIONS

ITEM	SEGMENT TIME (MIN)	TOTAL TIME AT END OF SEGMENT (MIN)	ALT	POWER SETTING (VDC) HOT DAY	POWER SETTING (VDC) COLD DAY	STEADY-STATE DATA
1	0.2	0.2	1,500 ft.	+3.65	-7.15	
2	5.0	5.2	Climb to 2500 ft.	+1.00	-7.15	
3	69.8	75.0	2500 ft.	Cycle 4*	Cycle 1*	7 Data Points, Hot Day
4	23.67	98.67	2500 ft.	Cycle 5*	Cycle 2*	1 Data Point, Hot Day
5	2.67	101.34	Climb to 6000 ft.	----	----	
5A	0.83			+3.65	+3.65	Climb to 6000 ft is completed in two segments at different PLA settings.
5B	1.84			+1.00	0.00	
6	37.16	138.5	6000 ft.	+1.00	0.00	2 Data Points
7	3.0	141.5	Descent to 2500 ft	-7.15	-7.15	
8	57.75	199.25	2500 ft.	Cycle 5*	Cycle 2*	2 Data Points Hot Day
9	1.5	200.75	Descent to 600 ft	-7.15	-7.15	
10	24.25	225	600 ft.	+1.0	0.0	1 Data Point
11	15.0	240	600 ft.	+1.0	0.0	1 Data Point
12	50.0	290	600 ft.	Cycle 6*	Cycle 3*	
13	10.0	300	600 ft.	+3.65	+3.65	2 Data Points

*Terrain-Following Cycles defined in Phase II QTP (CMEP 91-4043G), Paragraph 3.2.4.

TABLE 3-V. ENGINE 828/BUILD 6, OIL SAMPLE ANALYSIS DATA PROVIDED BY AEDC

(VALUES EXPRESSED IN PPM)

DATE	AEDC SAMPLE NO.	ENGINE BUILD TIME	TIME SINCE OIL CHANGE	FE	AG	AL	CR	CU	MG	NI	PB	SI	SN	TI	MO	K
4-1-80	0041-8	4:55	1:08	-	-	0.02	-	0.03	-	-	-	0.05	-	-	-	-
4-12-80	0043-109	12:52	5:11	0.6	0.06	0.4	0.2	0.1	-	0.1	0.05	0.4	-	0.1	-	0.04
4-15-80	0043-147	19:10	5:49	0.6	0.1	0.3	0.08	0.06	0.02	0.08	-	0.2	-	0.2	-	-
4-16-80	0043-156	19:36	0:26	0.3	0.03	0.05	0.03	0.03	-	0.03	-	0.05	-	-	-	-

NOTE: Reference Appendix G of this text for detailed reports from which this table is derived.

TABLE 3-VI. ENGINE 828/BUILD 6, OIL CONSUMPTION SUMMARY

DATE	RUN TIME	STARTS	OIL CONSUMPTION RATE	COMMENTS
4-1-80	1:35	1 Air	0.011 gal/hr	Calibration
4-12-80	5:11	1 Air	0.015 gal/hr	Hot Day Mission Simulation
4-15-80	5:49	1 Crtg	0.007 gal/hr	Cold Day Mission Simulation
4-16-80	0:26	1 Air	0.041 gal/hr	Calibration

TABLE 3-VII. ENGINE 828/BUILD 6, OIL AND BEARING TEMPERATURE AND OIL PRESSURES RECORDED DURING TESTING AT AEDC (INDIVIDUAL TEST PERIOD CONTENT DETAILED IN TABLE 3-IX)

AEDC TEST PERIOD	AEDC DATA POINT	ALTITUDE (FEET)	MACH NO.	CLIMATE (DAY)	PLA (VOLTS)	INLET AIRFLOW DISTORTION SCREEN	LP[1] SPOOL SPEED (RPM)	HP[1] SPOOL SPEED (RPM)	BEARING AND SCAVENGE OIL TEMPERATURES (°F) NO. 1 (TB1)	NO. 2 (TB2)	NO. 3 (TB3)	NO. 4/5 (TB4/5)	NO. 6 (TB6)	SYSTEMIC OIL PRESS (PSIA)	SYSTEMIC OIL TEMP (°F)
21	13	SL	0.70	STD	+3.61	None	31973	62413	255	395	342	397	322	100	245
	14	SL	0.70	STD	+2.18	None	30751	60968	249	379	329	380	306	96	240
	15	SL	0.70	STD	+0.98	None	29517	59575	240	363	317	362	290	94	234
22	2	2500	0.70	HOT	+3.65	GD-1	31025	62212	274	416	366	422	347	91	284
	4	2500	0.70	HOT	+3.65	GD-1	31006	62191	278	416	367	423	347	91	285
	6	2500	0.70	HOT	+3.65	GD-1	30981	62160	277	416	367	423	347	91	285
	8	2500	0.70	HOT	+3.65	GD-1	30987	62161	281	416	367	423	347	91	286
	9	2500	0.70	HOT	+3.65	GD-1	30991	62169	277	414	366	422	346	91	285
	10	6000	0.70	HOT	+0.99	GD-1	28786	59317	244	378	338	383	312	85	271
	12	2500	0.70	HOT	+3.65	GD-1	30964	62142	275	415	366	420	345	91	285
	14	600	0.70	HOT	+0.99	GD-1	28289	59379	269	390	348	392	320	86	278
	16	600	----[2]	HOT	+3.66	GD-1	30694	62143	287	420	374	425	352	92	292
23	2	SL	0.70	STD	+0.98	None	29469	59510	243	358	313	360	288	94	230
	4	SL	0.70	STD	+2.20	None	30712	60890	255	378	328	378	305	97	238
	8	SL	0.70	STD	+3.66	None	32000	62348	263	396	343	397	322	100	246
24	3	2500	0.70	COLD	-2.17	GD-1	26927	54403	148	254	219	242	181	103	150
	4	6000	0.70	COLD	0.00	GD-1	30183	58308	192	307	256	300	229	103	169
	6	600	0.70	COLD	0.00	GD-1	30912	57698	186	297	245	271	210	115	152
	8	600	----[2]	COLD	+3.65	GD-1	31599	59262	205	320	268	298	233	113	165
25	4	SL	0.70	STD	+2.18	None	30597	60922	258	375	326	373	302	99	237
	6	SL	0.70	STD	+3.62	None	31935	62382	267	393	342	393	318	101	243
	8	SL	0.70	STD	+0.97	None	29392	59591	251	362	317	360	289	95	233

[1]Uncorrected data

[2]This value classified

TABLE 3-VIII. ENGINE 828/BUILD 6, ENGINE VIBRATION LEVELS RECORDED DURING TESTING AT AEDC (INDIVIDUAL TEST PERIOD CONTENT DETAILED IN TABLE 3-IX)

AEDC		LP[1]	HP[1]	INLET	VIBRATION LEVELS			
TEST PERIOD	DATA POINT	SPOOL SPEED	SPOOL SPEED	CASE (RADIAL)	RADIAL (X)	TANGENTIAL (Y)	AXIAL (Z)	REAR HOUSING
21	13	31973	62413	4	6	7	7	NO DATA RECORDED DURING TESTING AT AEDC
	14	30751	60968	3	8	8	6	
	15	29517	59575	3	8	7.5	6	
22	2	31025	62212	3	6	6	5.5	
	4	31006	62191	3	5	6	6.5	
	6	30981	62160	3	6	6	6	
	8	30987	62161	3.5	5.5	6	7	
	9	30991	62169	3	5	6	7	
	10	28786	59317	3.5	6	5.5	6	
	12	30964	62142	3	6	6	6.5	
	14	28289	59379	3	6	6	6	
	16	30694	62143	3	6	6	6	
23	2	29469	59510	4	8	8	6	
	4	30712	60890	3	9	9	7	
	8	32000	62348	4	7	6	7	
24	3	26927	54403	3	5	4	4	
	4	30183	58308	4	6	6	6	
	6	30912	57698	4	7	6	8	
	8	31599	59262	4	6	6	8	
25	4	30597	60922	4	8	8	6	
	6	31935	62382	4	6	6	8	
	8	29342	59591	4	7	7	6	

[1]Uncorrected data

TABLE 3-IX. ENGINE 828/BUILD 6, QUALIFICATION TESTING AT AEDC, INDIVIDUAL TEST PERIOD CONTENT.

AEDC TEST PERIOD	OBJECTIVE	RESULTS
21	Set engine maximum governed HP spool speed[1], conduct engine checkout and trim check runs	Completed
22	Conduct hot day mission simulation test	Completed, some high EGT levels observed
23	Recertification calibration	Completed, one individual EGT thermocouple reporting erratically
24	Conduct cold day mission simulation test	Completed, facility problems caused freezing of test cell fuel filter and loss of inlet airflow temperature control late in mission, "sparking" from tailpipe observed
25	Post-test calibration	Completed, some sparking from tailpipe, debris on magnetic drain plug

[1] Due to installation of replacement fuel control unit at AEDC (reference paragraph 3.3.2.2.1)

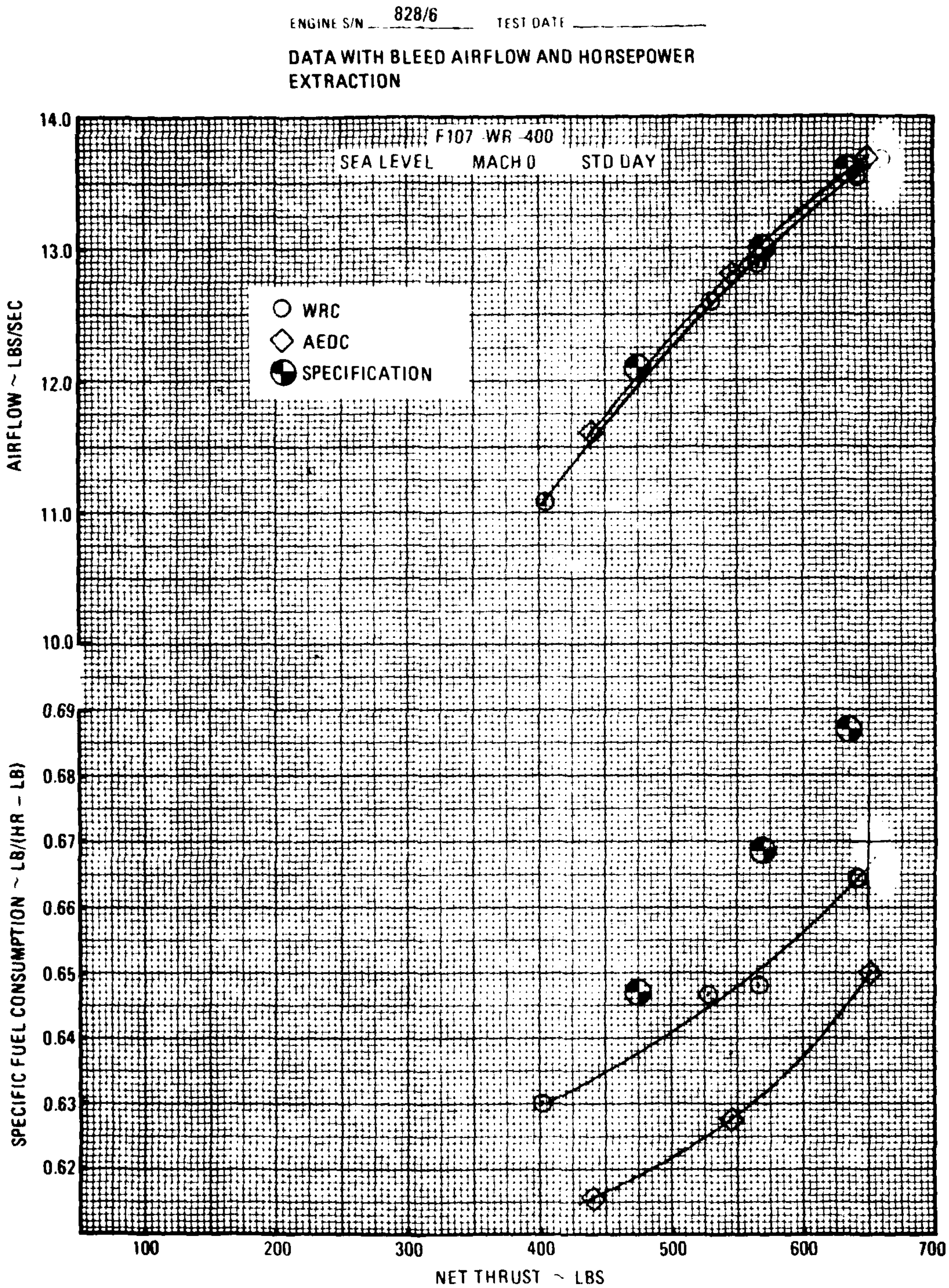


Figure 3-1. Engine 828/Build 6, Airflow and Specific Fuel Consumption versus Net Thrust, Comparison of WRC and AEDC Data (Sea Level, Static, Standard Day)

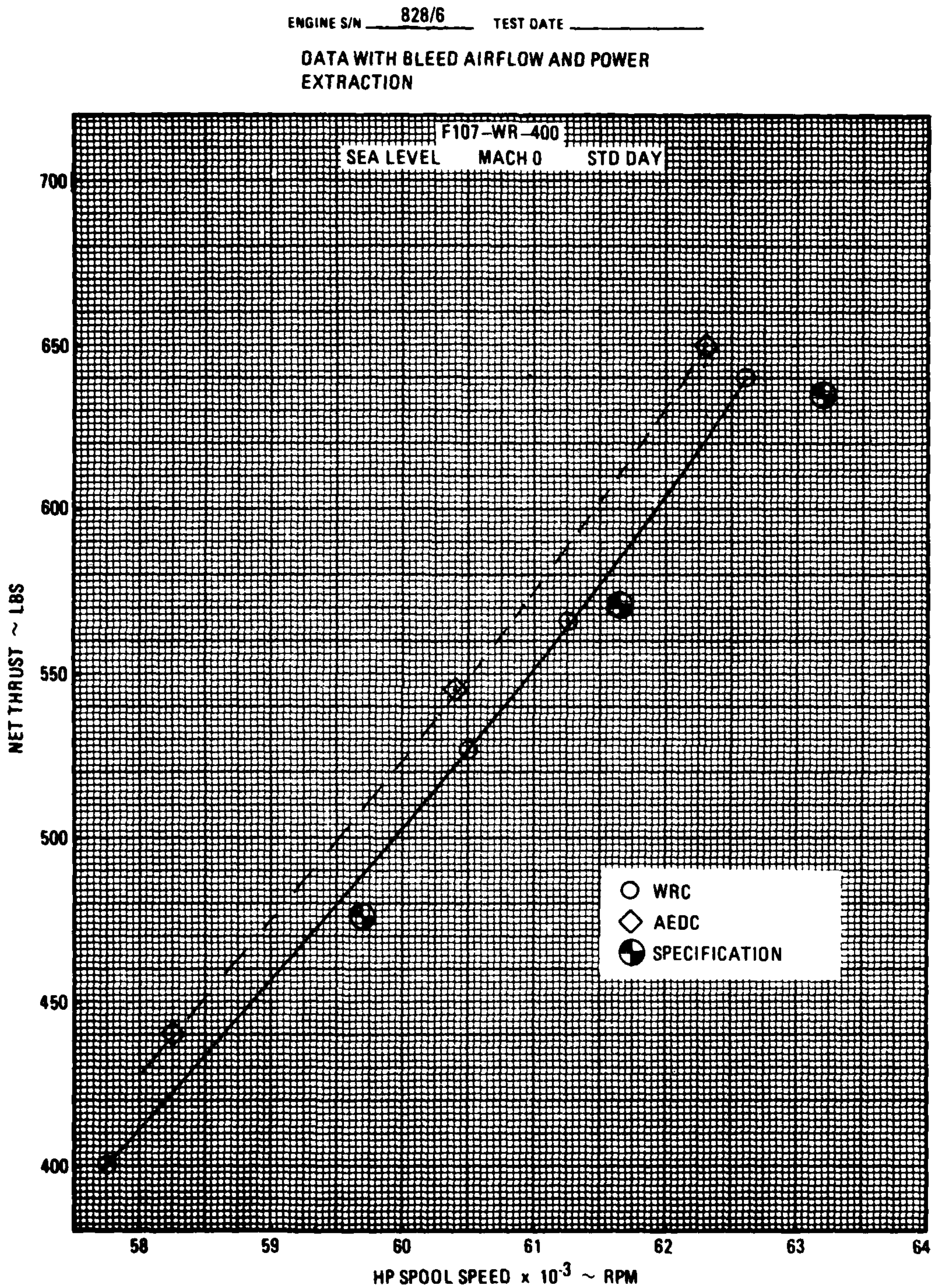


Figure 3-2. Engine 828/Build 6, Net Thrust versus HP Spool Speed, Comparison of WRC and AEDC Data (Sea Level, Static, Standard Day)

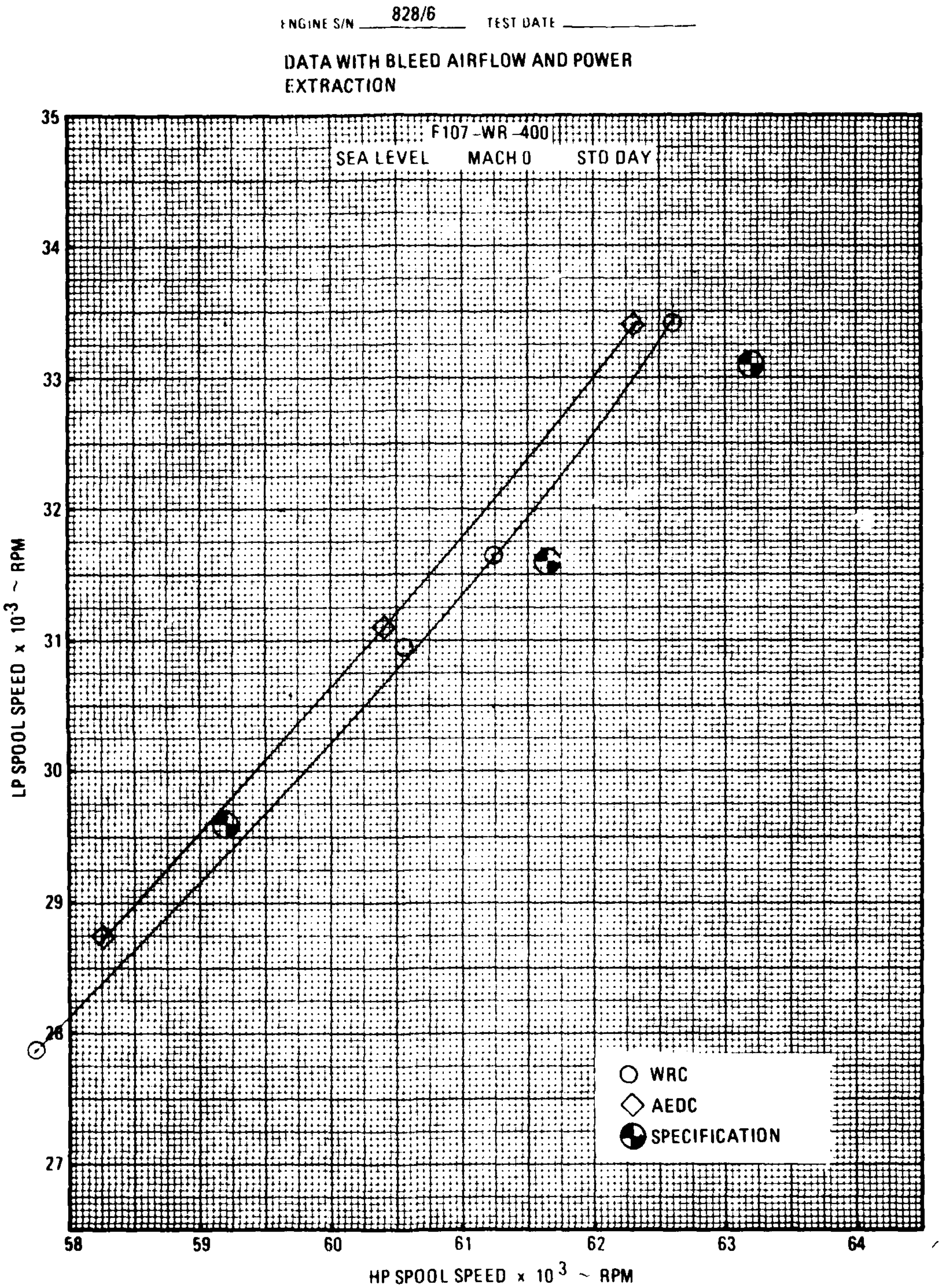


Figure 3-3. Engine 828/Build 6, LP Spool Speed versus HP Spool Speed, Comparison of WRC and AEDC Data (Sea Level, Static, Standard Day)

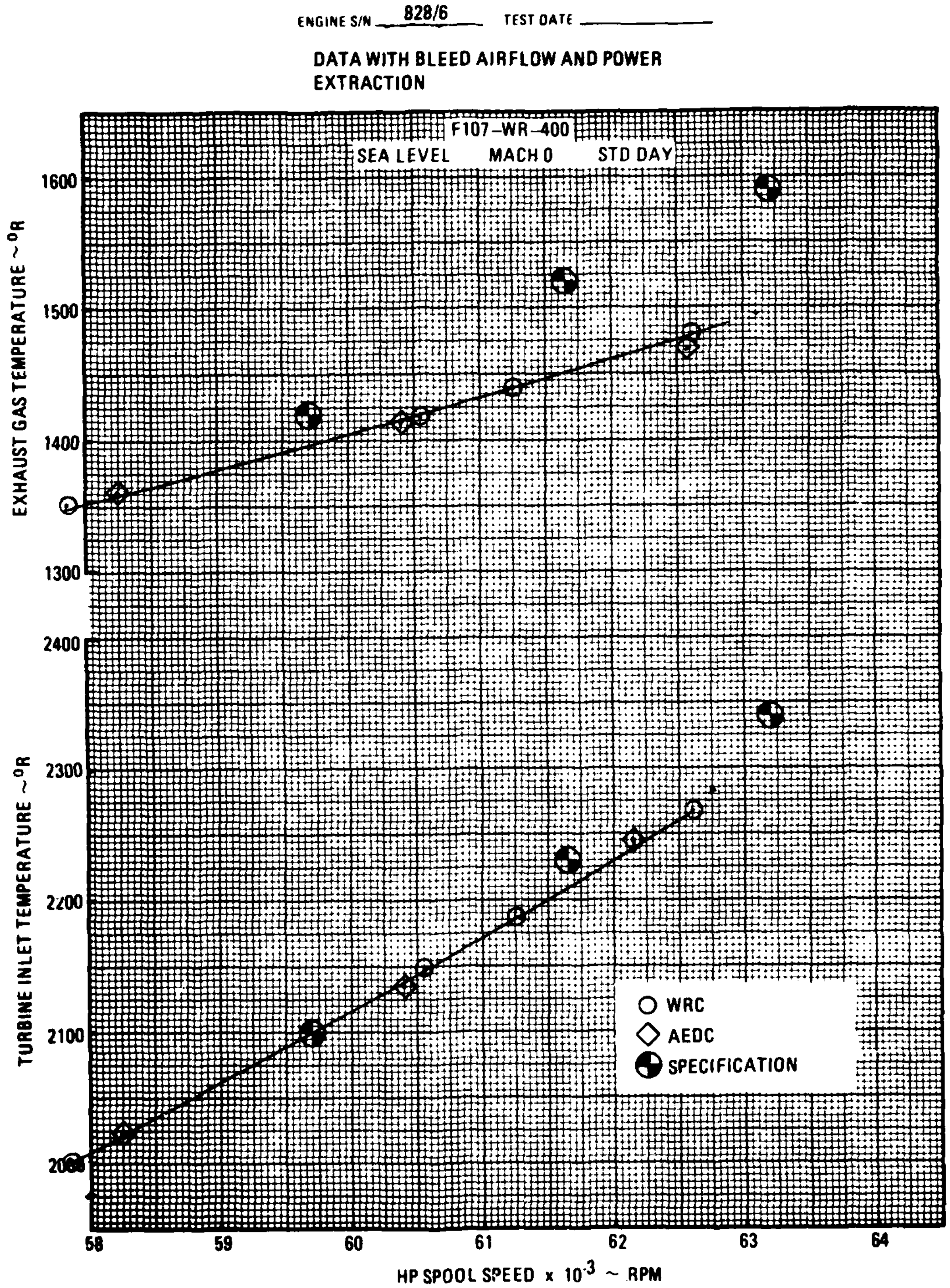


Figure 3-4. Engine 828/Build 6, Exhaust Gas Temperature and Turbine Inlet Temperature versus HP Spool Speed, Comparison of WRC and AEDC Data (Sea Level, Static, Standard Day)

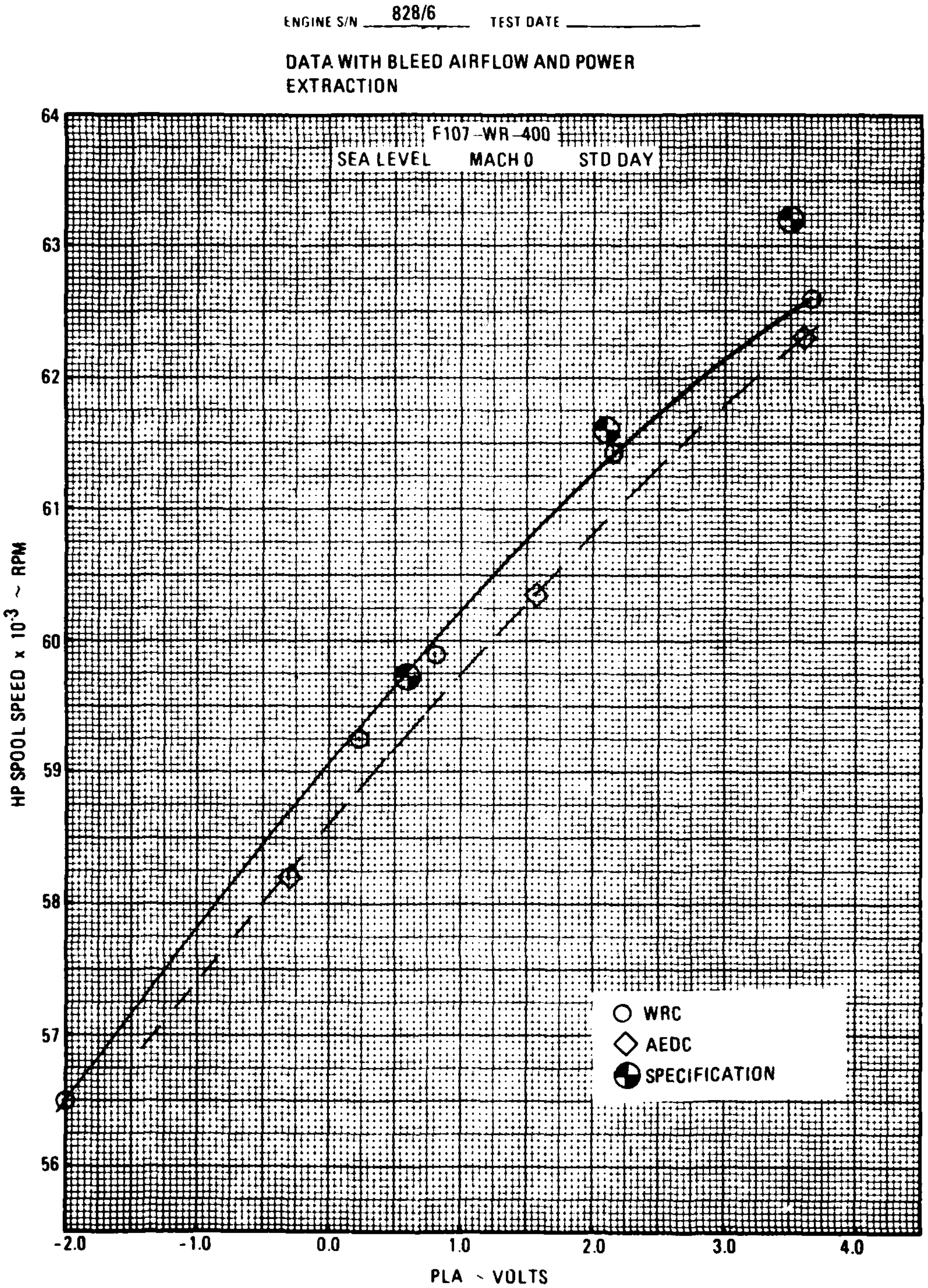


Figure 3-5. Engine 828/Build 6, HP Spool Speed versus PLA Volts, Comparison of WRC and AEDC Data (Sea Level, Static, Standard Day)

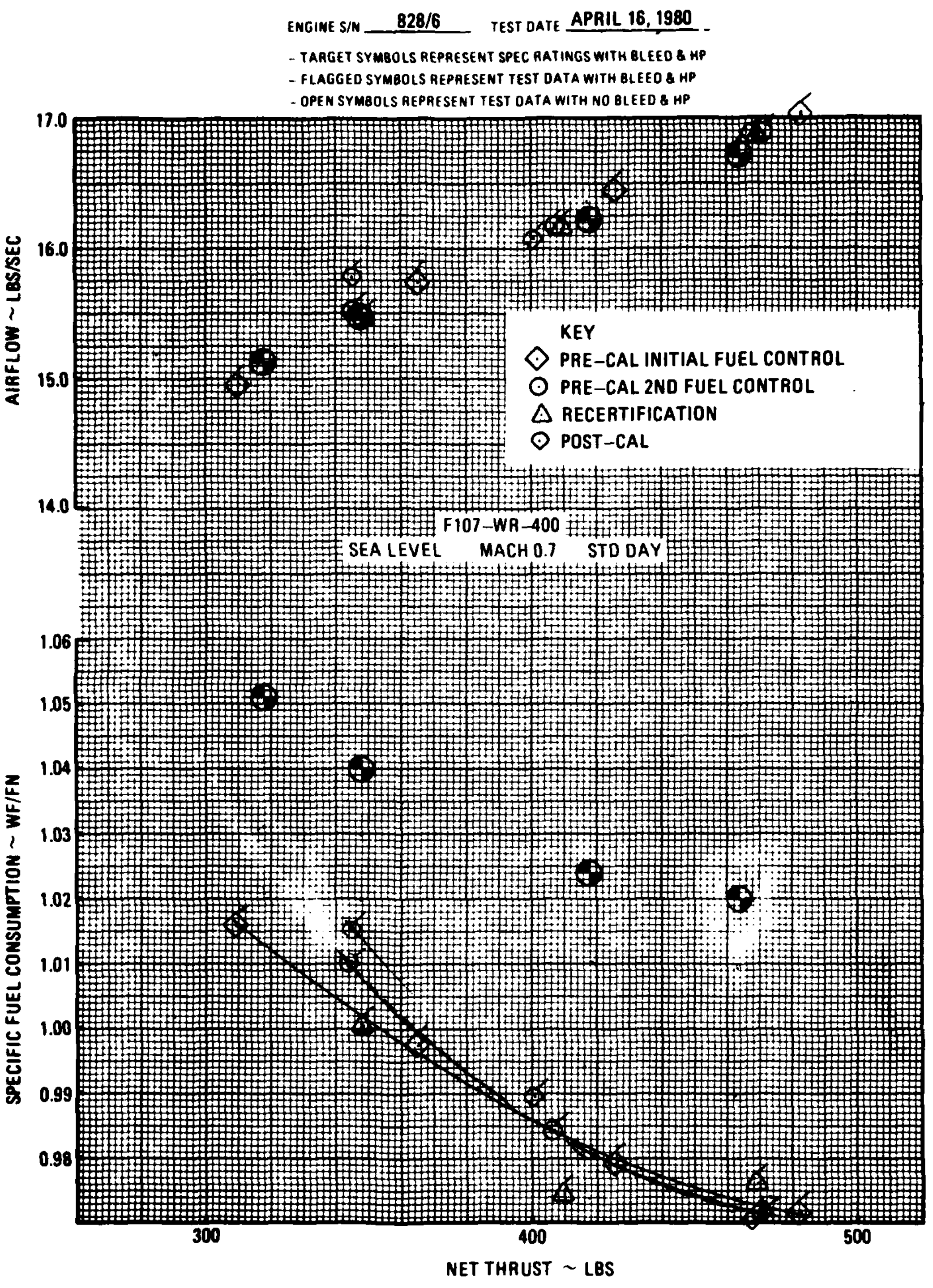


Figure 3-6. Engine 828/Build 6, Airflow and Specific Fuel Consumption versus Net Thrust, AEDC Performance Calibration Data (Sea Level, Mach 0.70, Standard Day)

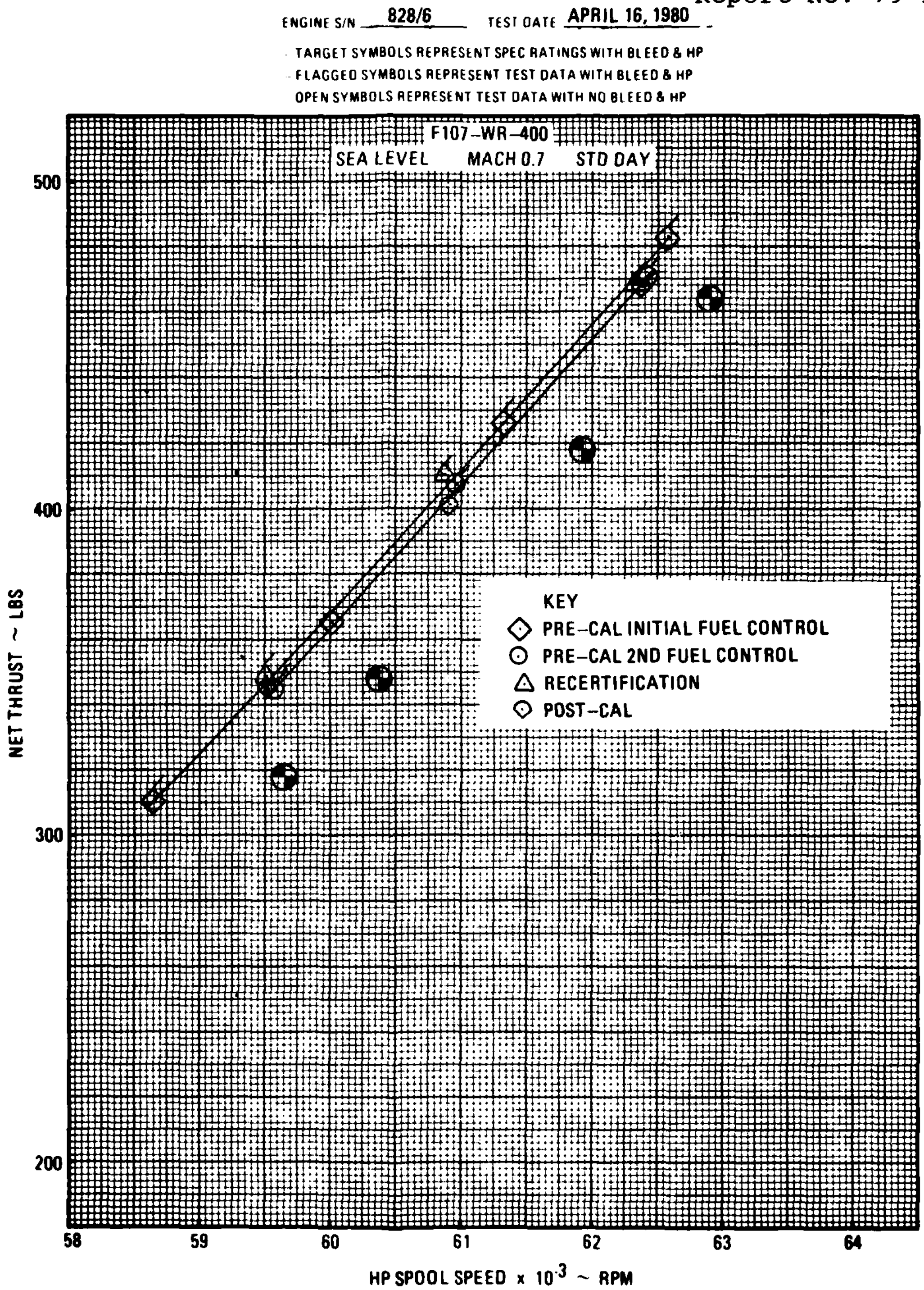


Figure 3-7. Engine 828/Build 6, Net Thrust versus HP Spool Speed, AEDC Performance Calibration Data (Sea Level, Mach 0.70, Standard Day)

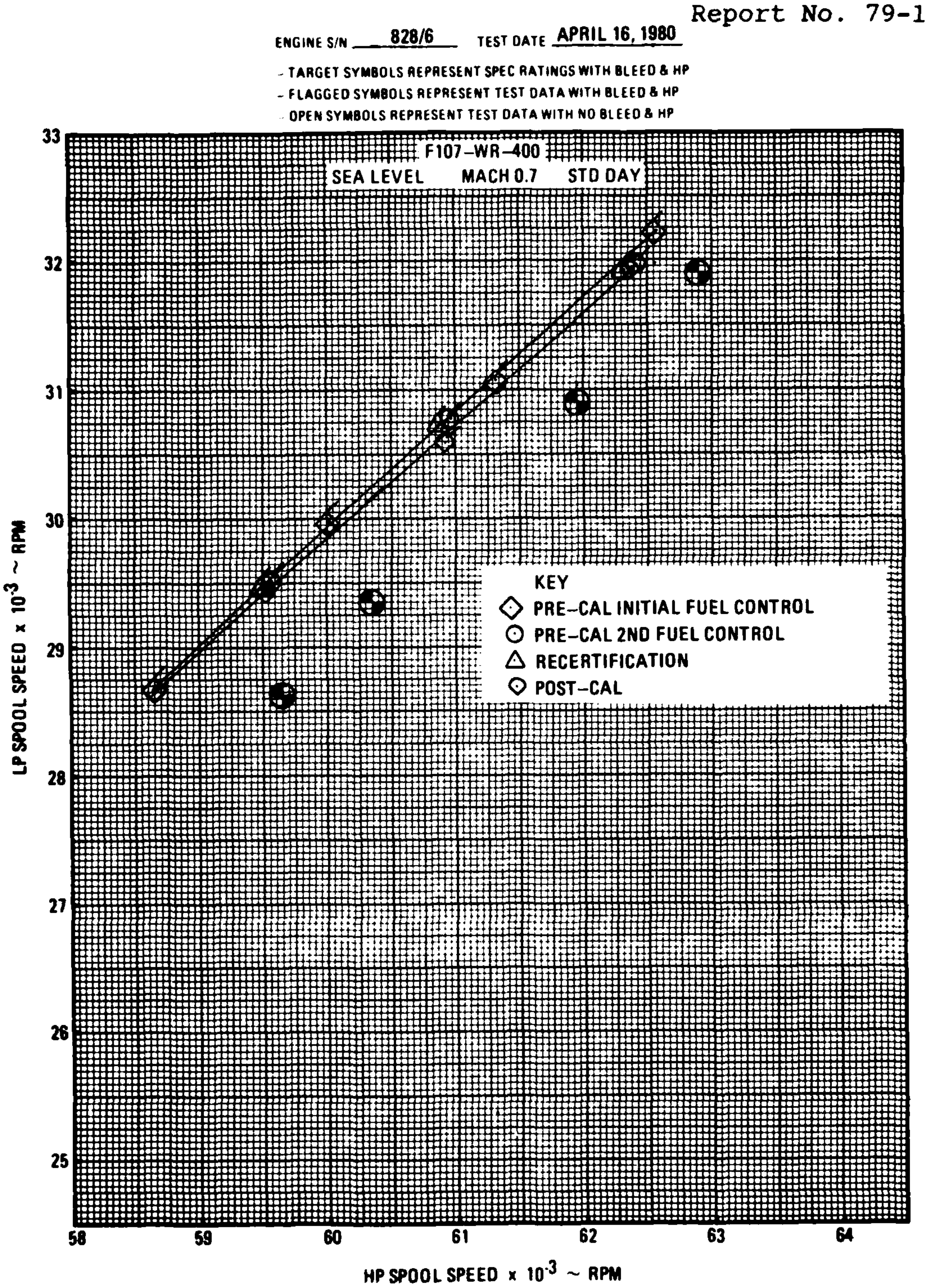


Figure 3-8. Engine 828/Build 6, LP Spool Speed versus HP Spool Speed, AEDC Performance Calibration Data (Sea Level, Mach 0.70, Standard Day)

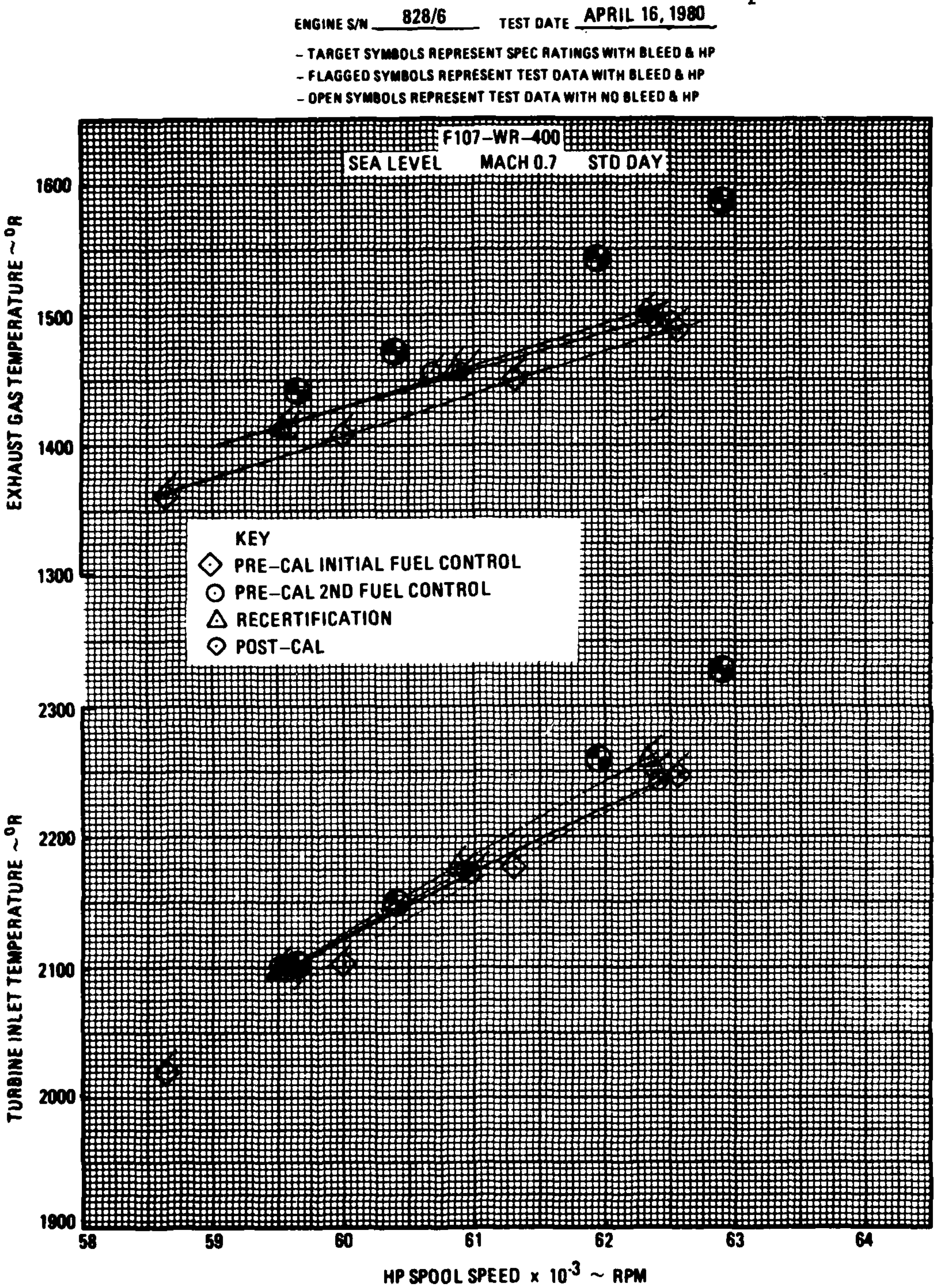


Figure 3-9. Engine 828/Build 6, Exhaust G. Temperature and Turbine Inlet Temperature versus HP S ol Speed, AEDC Performance Calibration Data (Sea Level, Mach 0.70, Standard Day)

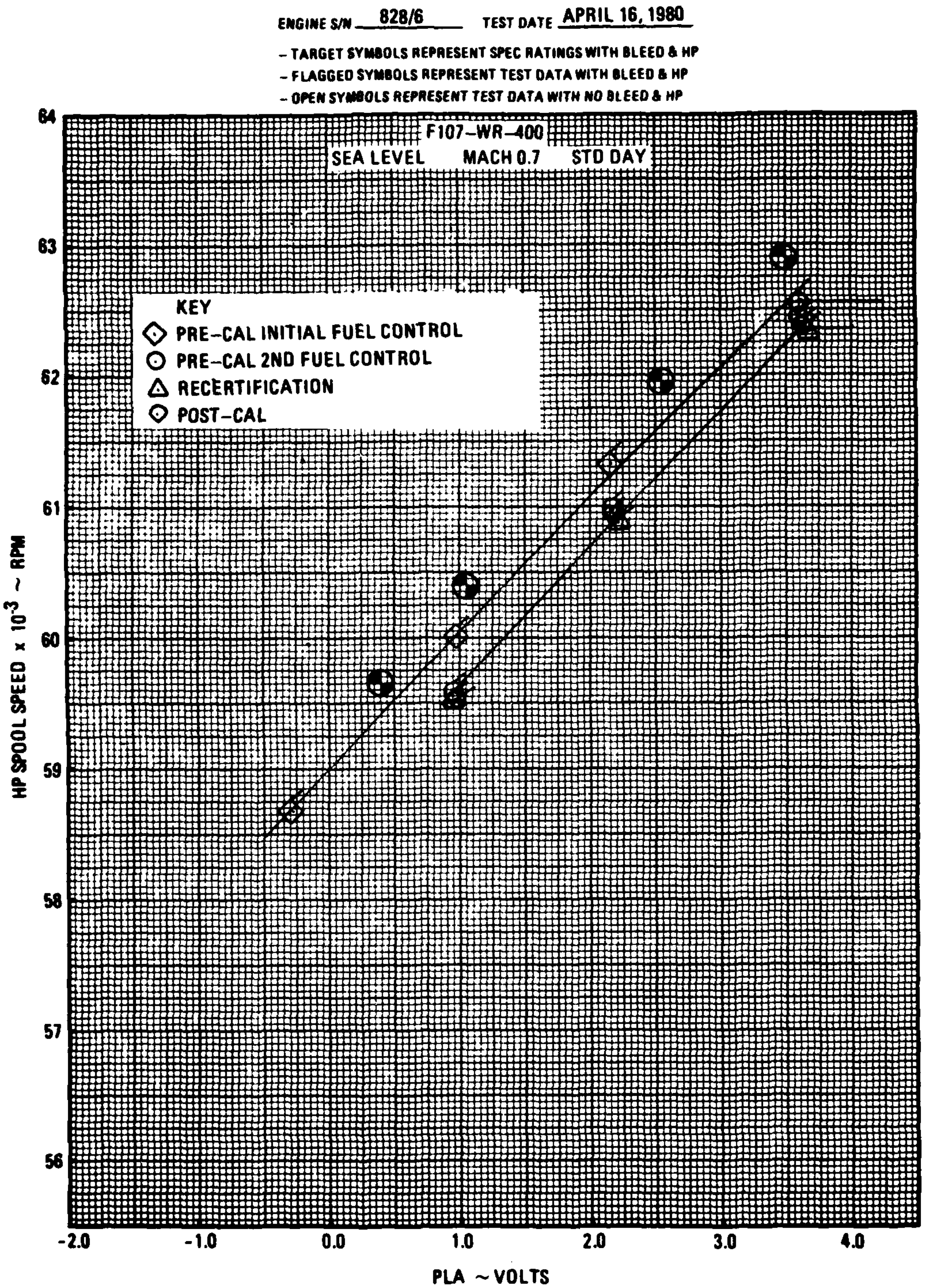


Figure 3-10. Engine 828/Build 6, HP Spool Speed versus PLA Volts, AEDC Performance Calibration Data (Sea Level, Mach 0.70, Standard Day)

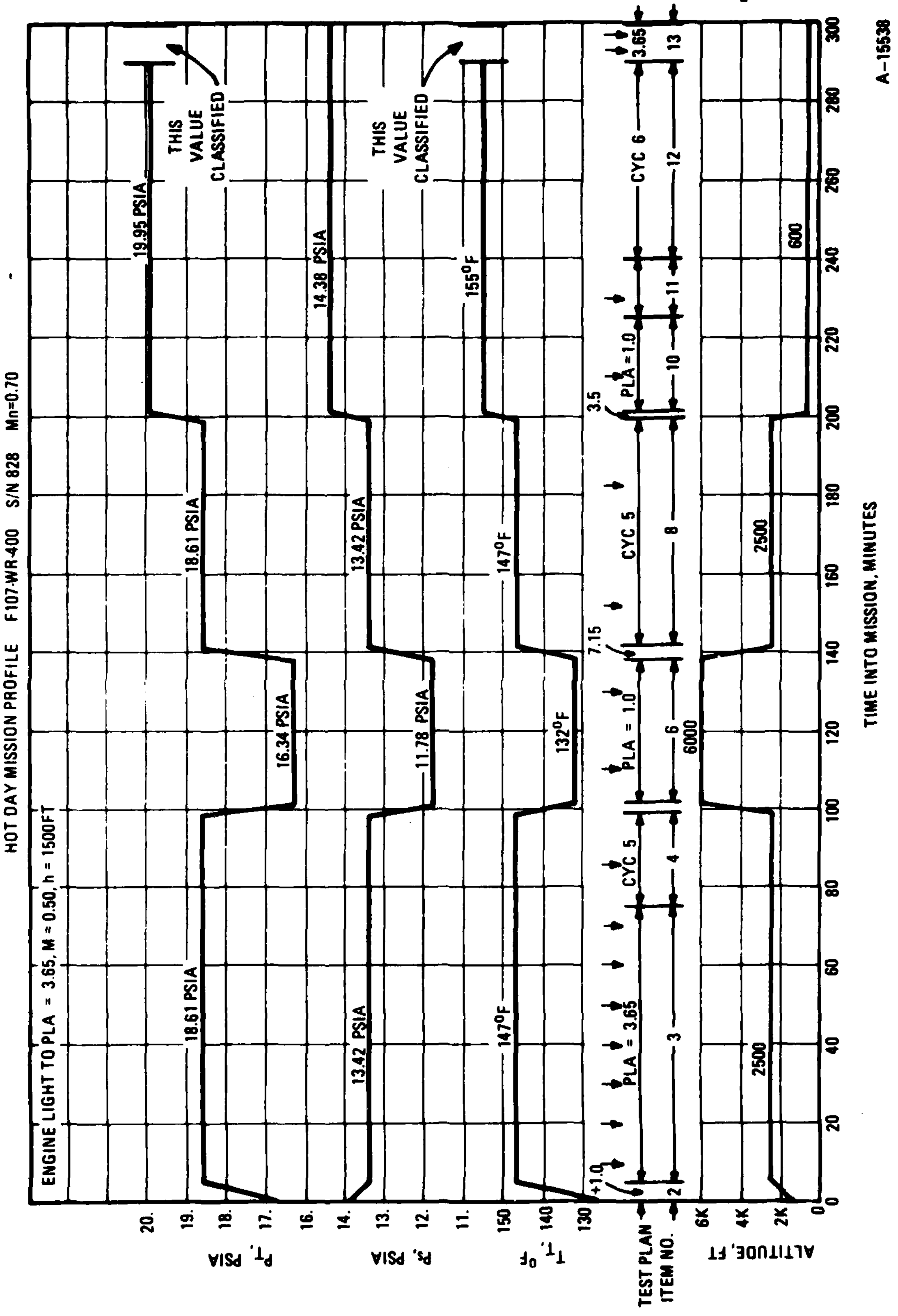


Figure 3-11. Hot-Day Mission Profile Requirements, Inlet Temperature and Pressure, Simulated Altitude

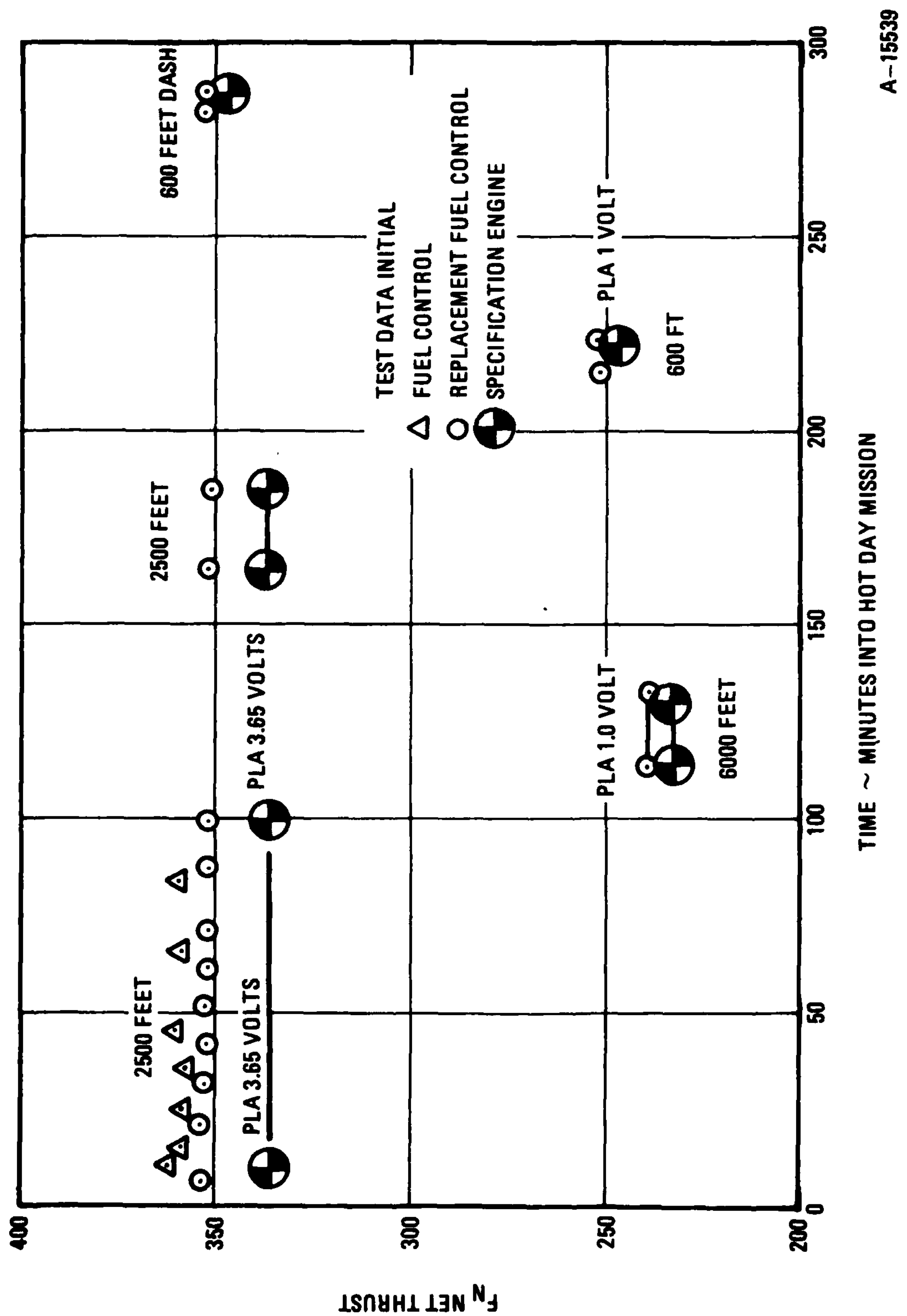


Figure 3-12. Engine 828/Build 6, Time History of Net Thrust, Hot Day Mission Simulation (Various Flight Conditions)

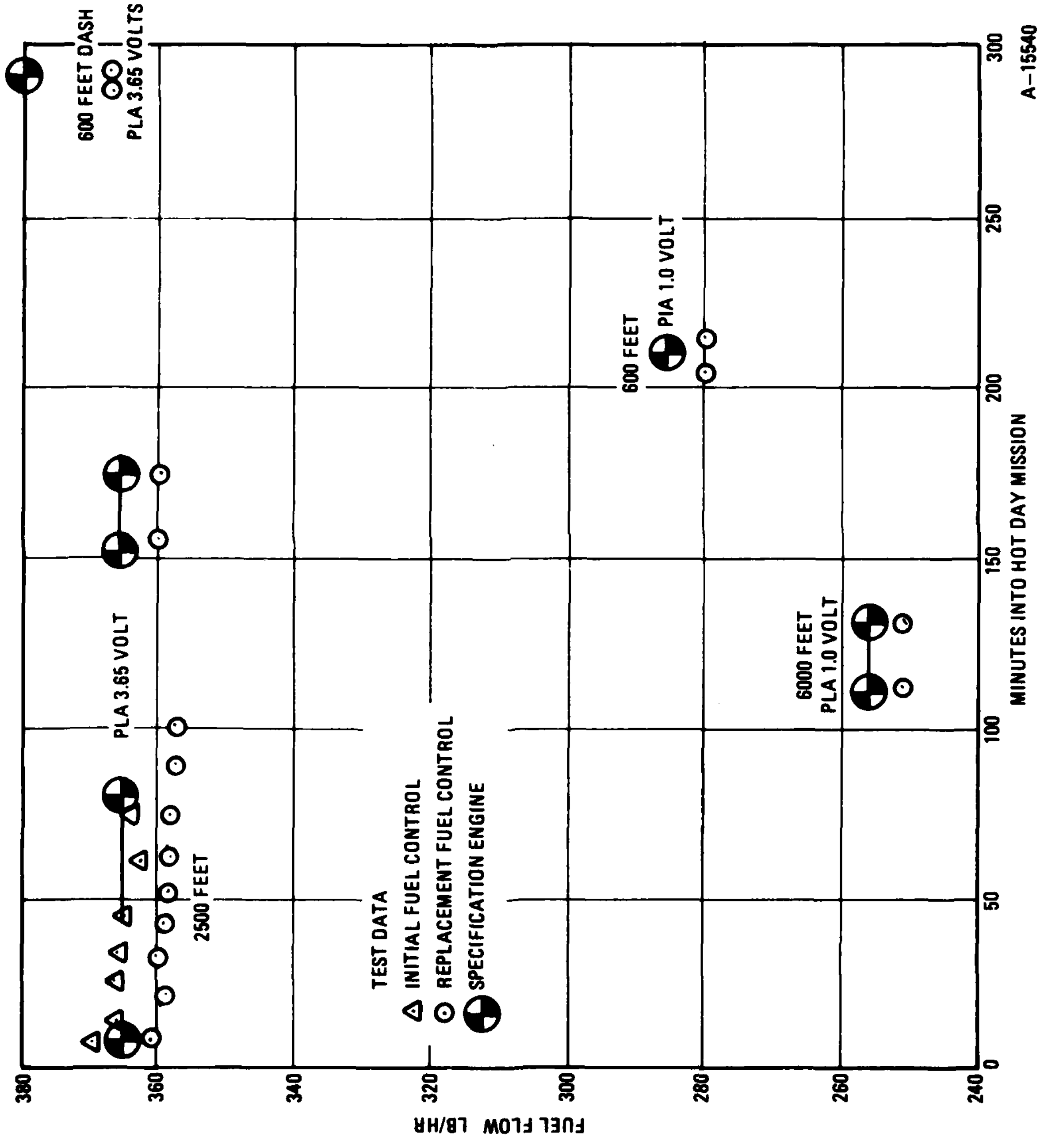


Figure 3-13. Engine 828/Build 6, Time History of Engine Fuel Flow, Hot Day Mission Simulation (Various Flight Conditions)

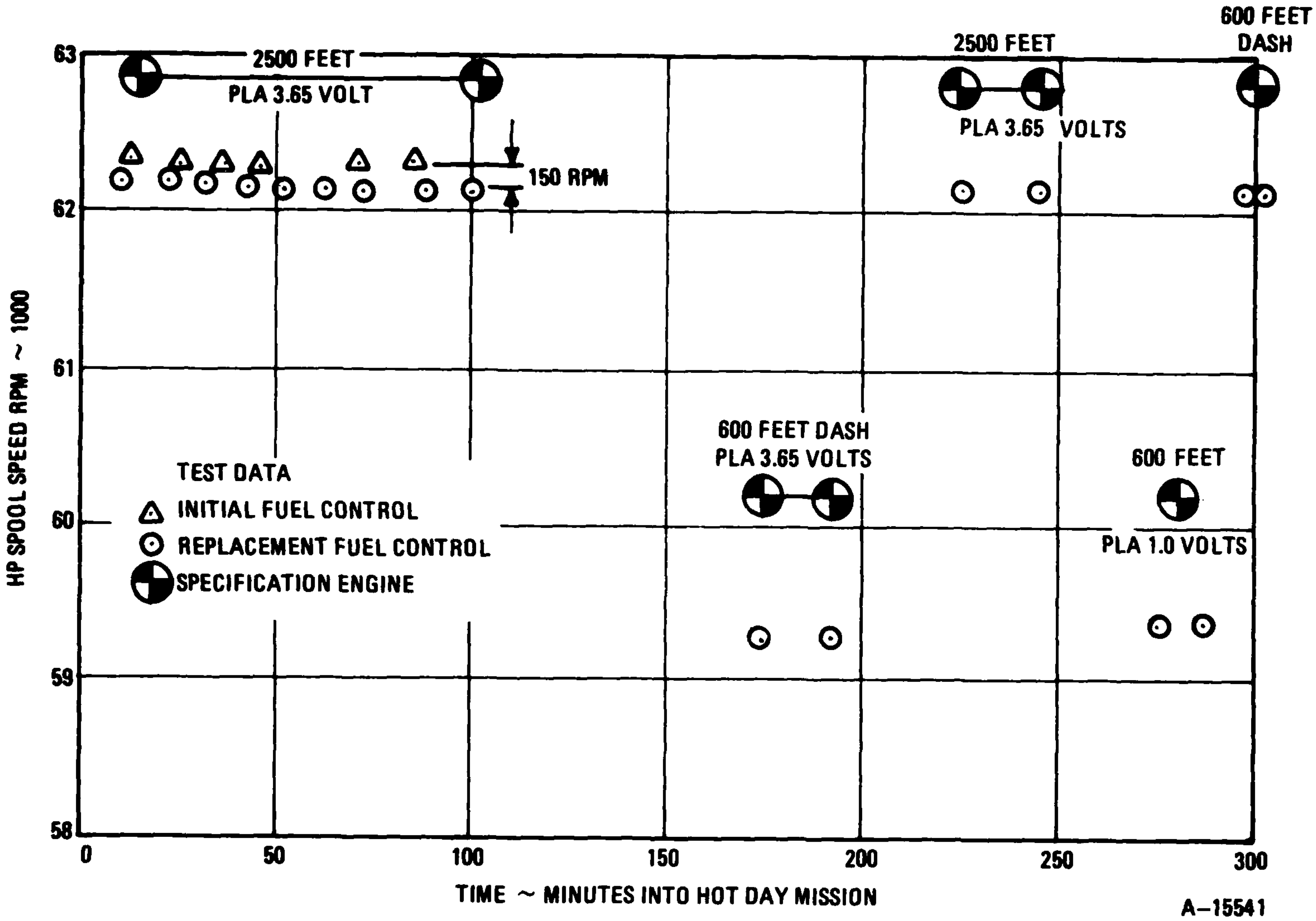


Figure 3-14. Engine 828/Build 6, Time History of HP Spool Speed, Hot Day Mission Simulation (Various Flight Conditions)

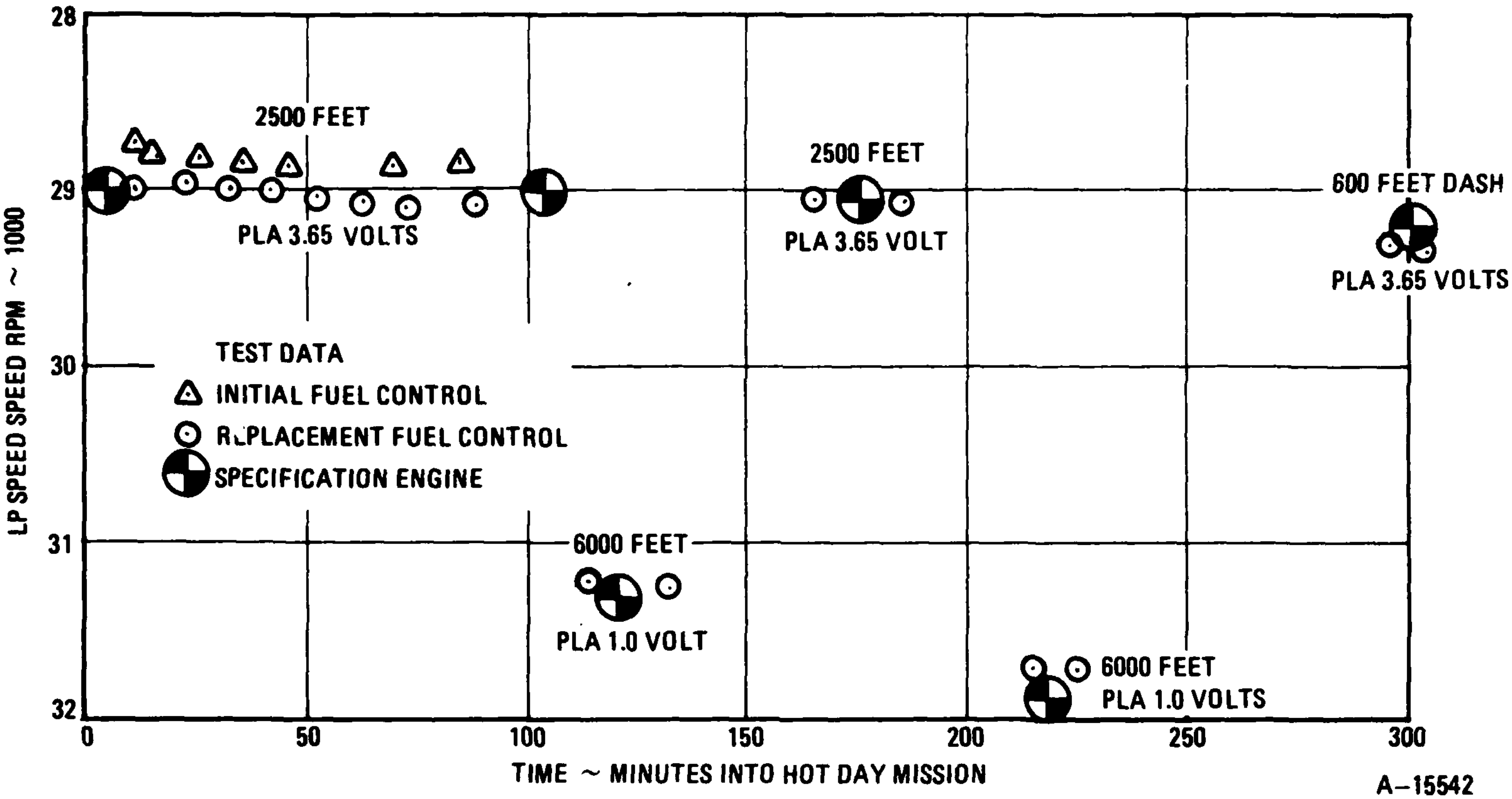


Figure 3-15. Engine 828/Build 6, Time History of LP Spool Speed, Hot Day Mission Simulation (Various Flight Conditions)

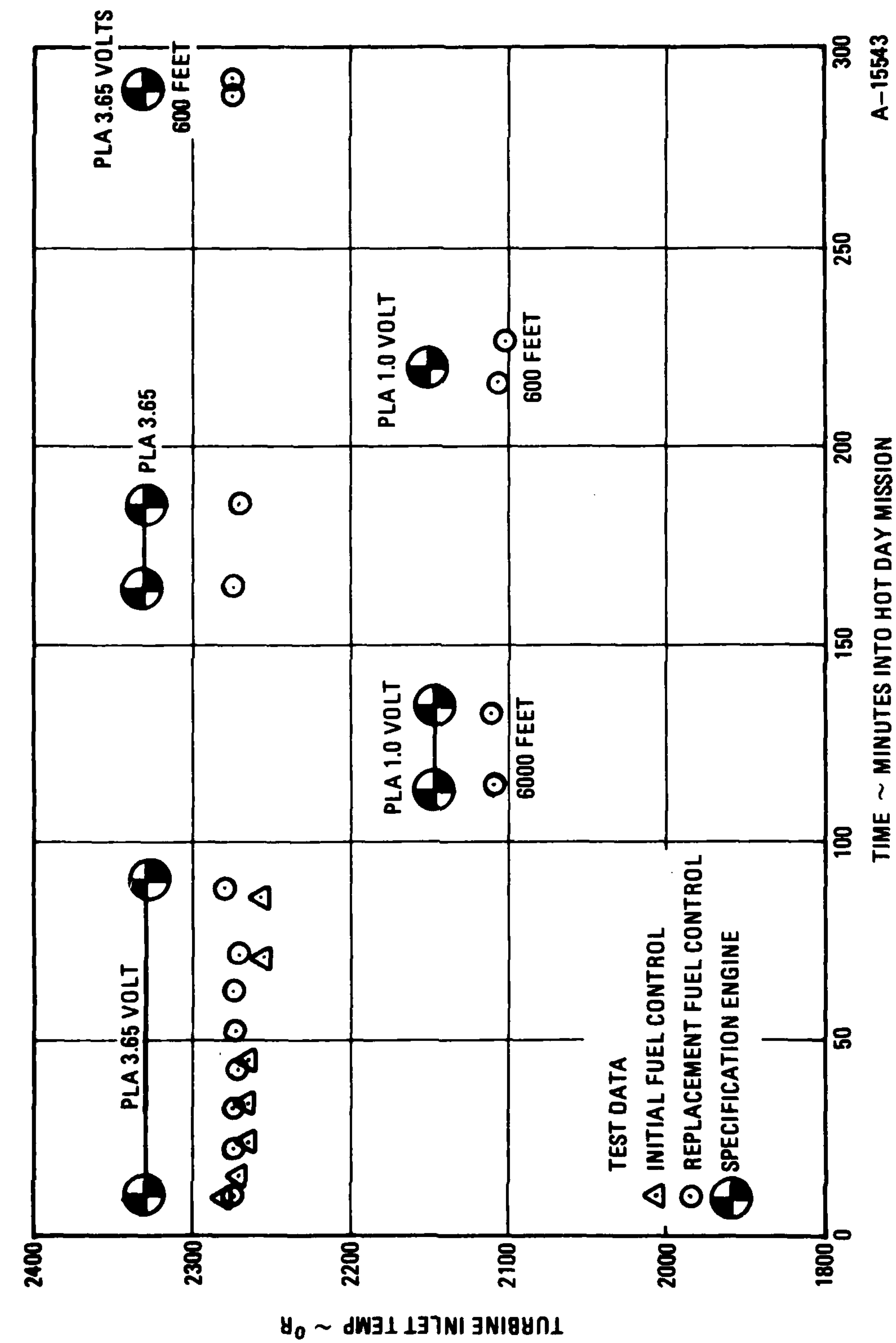


Figure 3-16. Engine 828/Build 6, Time History of Turbine Inlet Temperature, Hot Day Mission Simulation (Various Flight Conditions)

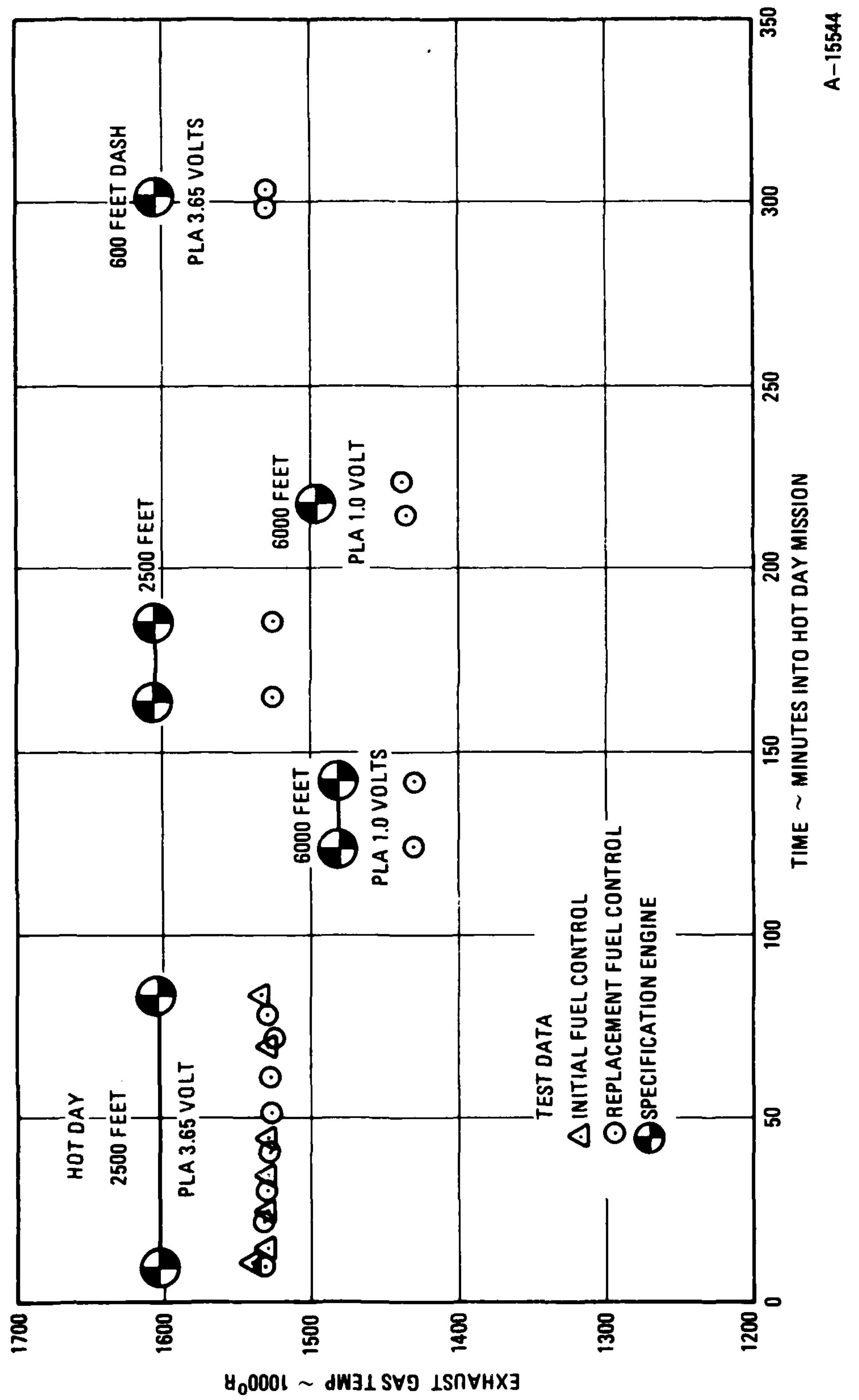


Figure 3-17. Engine 828/Build 6, Time History of Exhaust Gas Temperature, Hot Day Mission Simulation (Various Flight Conditions)

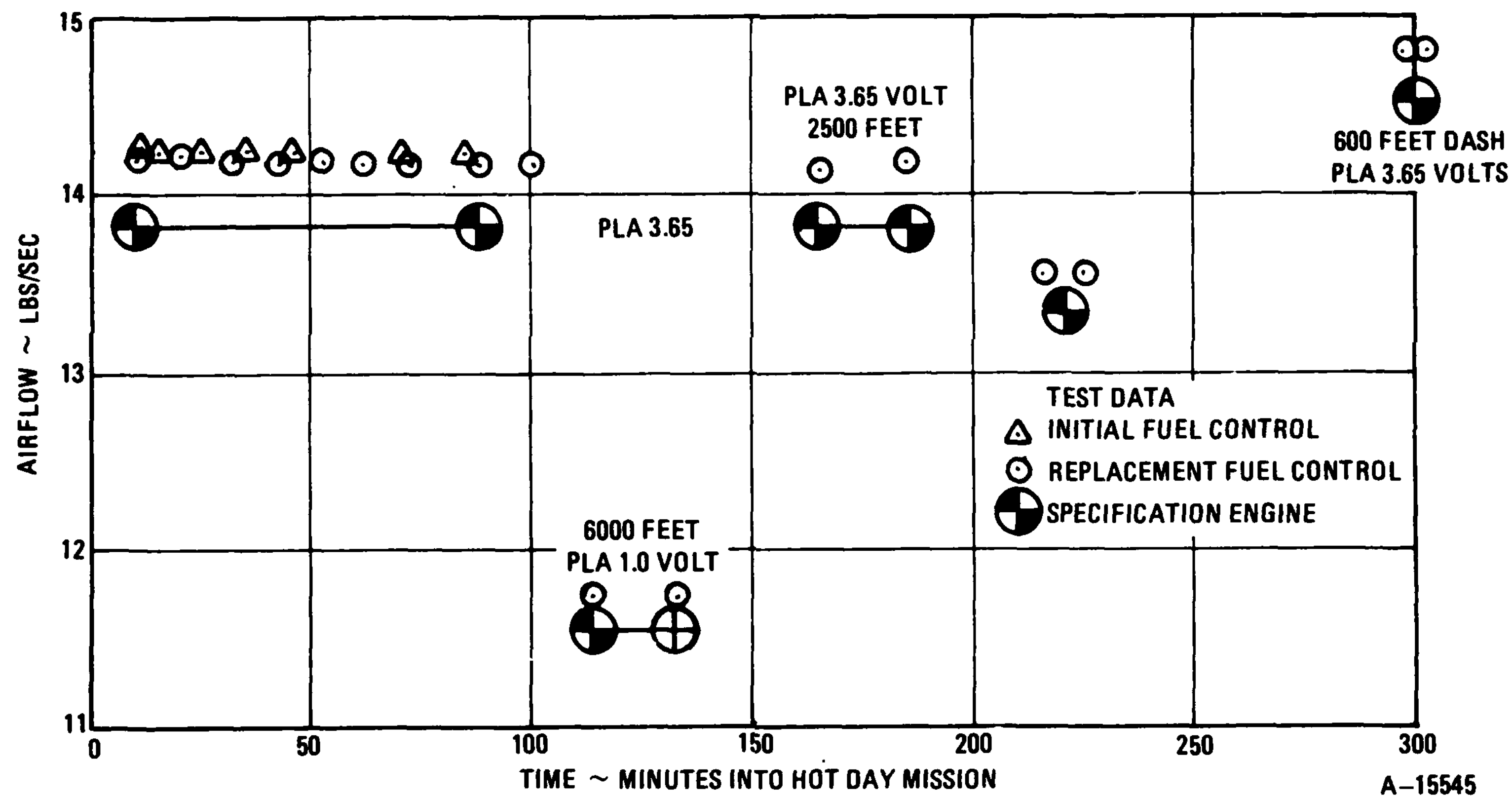


Figure 3-18. Engine 828/Build 6, Time History of Engine Airflow, Hot Day Mission Simulation (Various Flight Conditions)

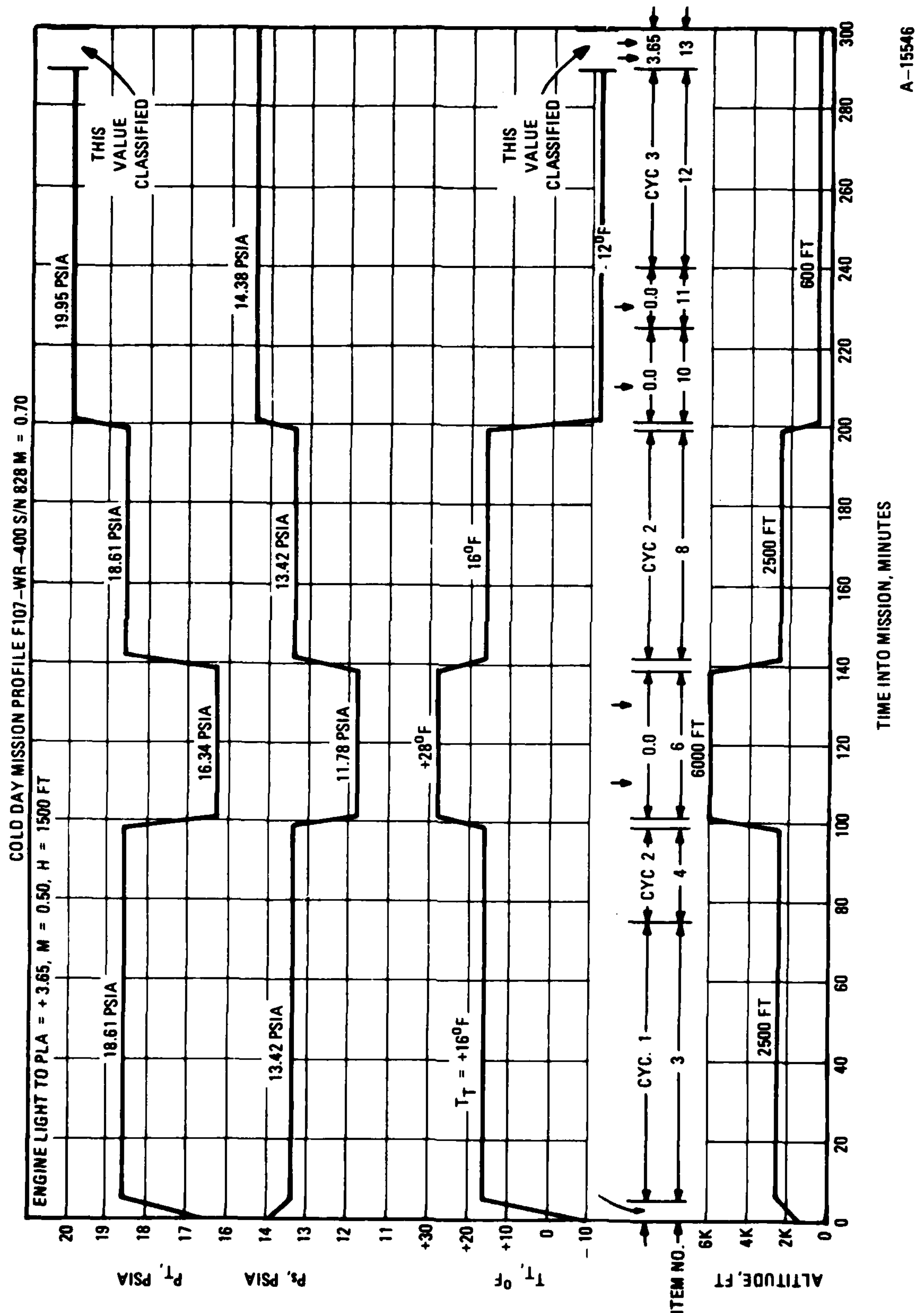


Figure 3-19. Cold Day Mission Profile Requirements, Inlet Temperature and Pressure, Simulated Altitude

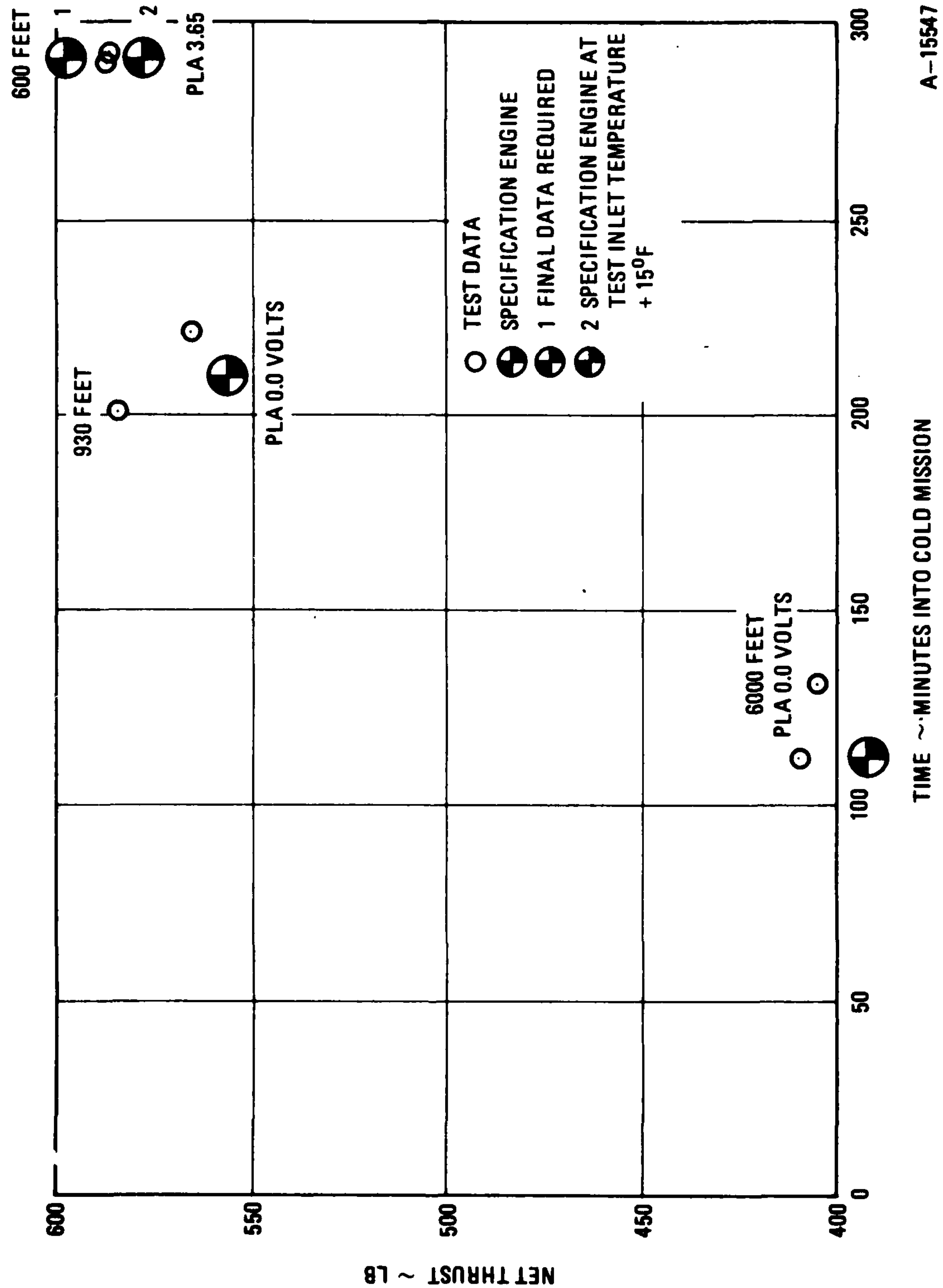


Figure 3-20. Engine 828/Build 6, Time History of Net Thrust, Cold Day Mission Simulation (Various Flight Conditions)

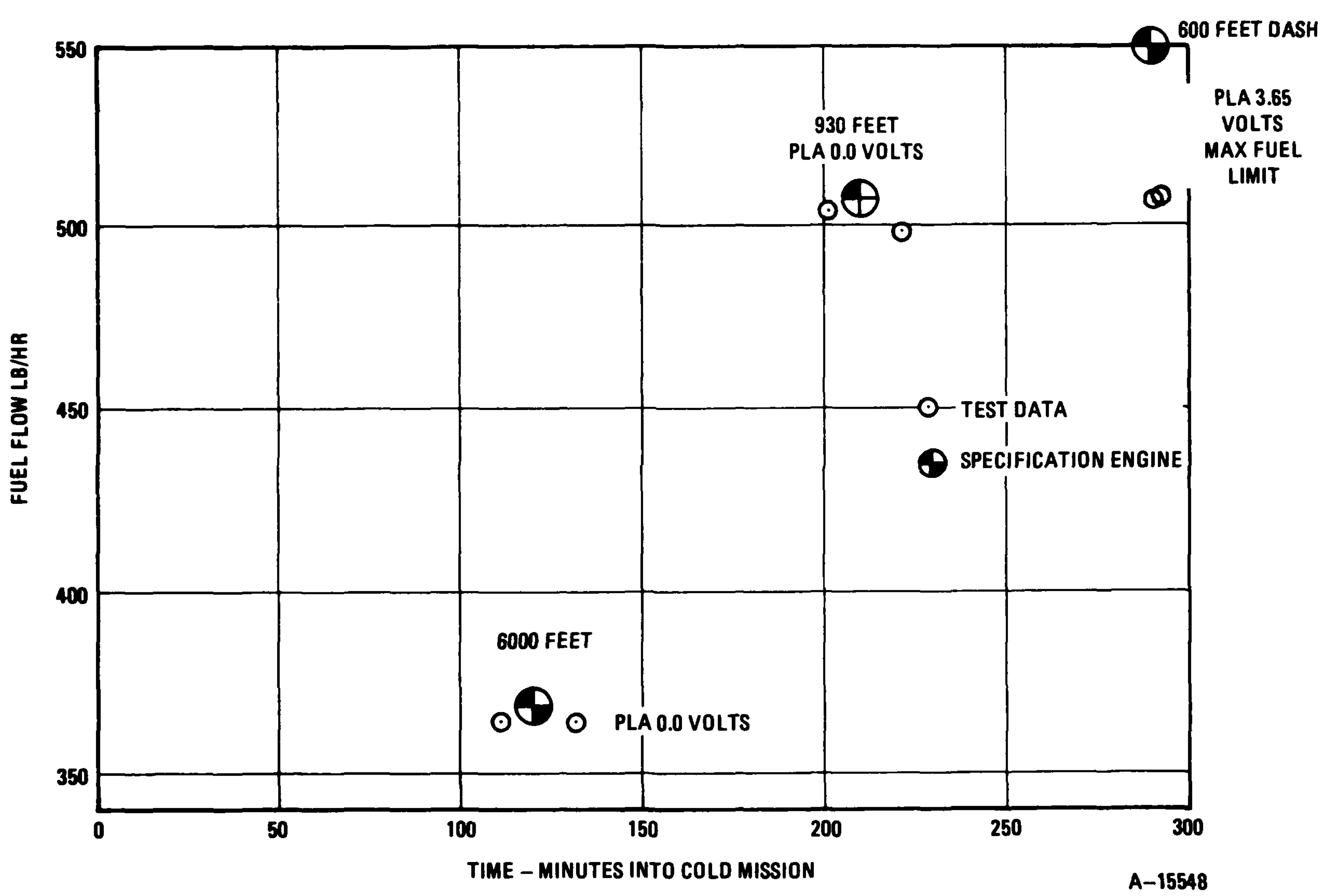


Figure 3-21. Engine 828/Build 6, Time History of Engine Fuel Flow, Cold Day Mission Simulation (Various Flight Conditions)

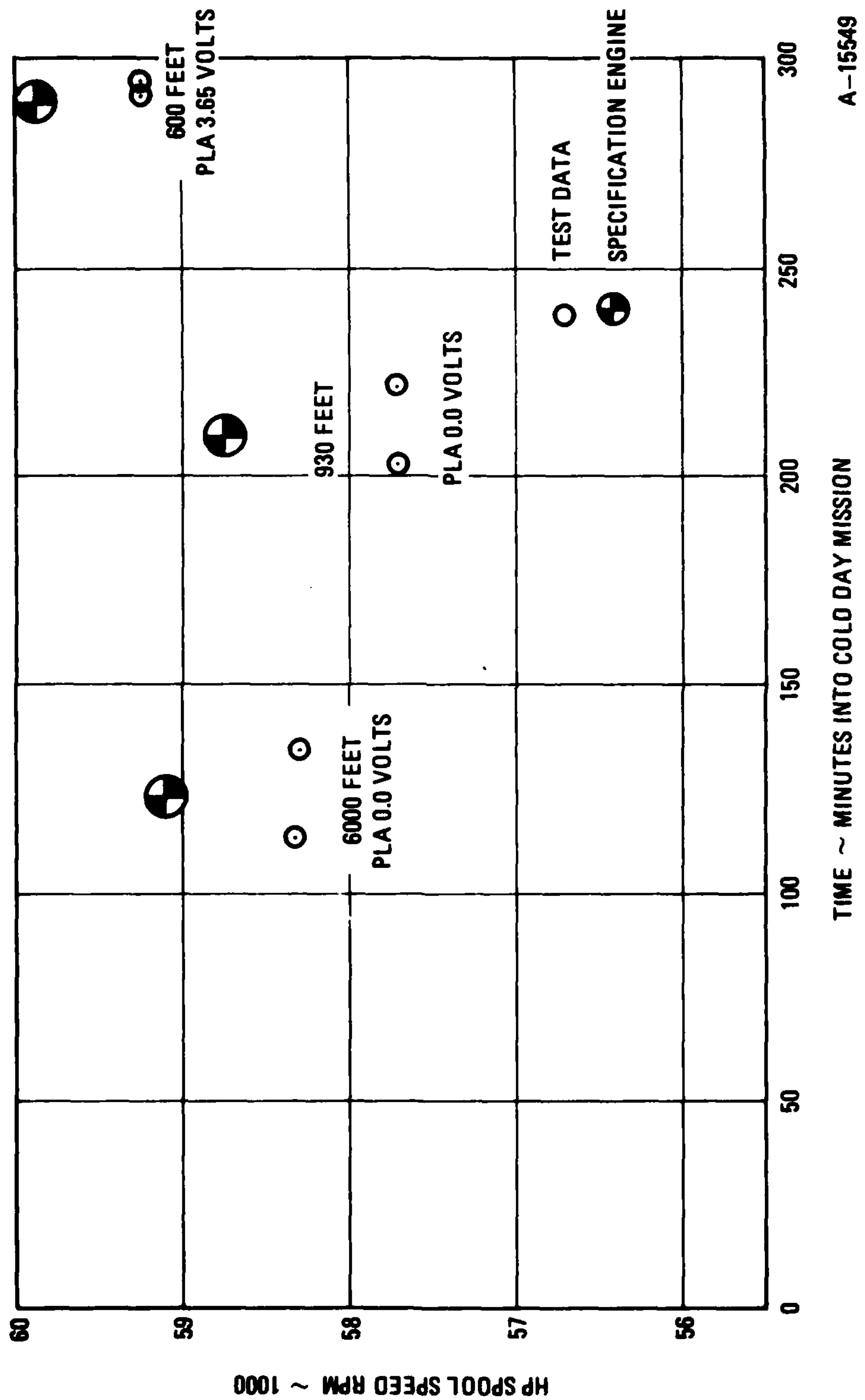


Figure 3-22. Engine 828/Build 6, Time History of HP Spool Speed, Cold Day Mission Simulation (Various Flight Conditions)

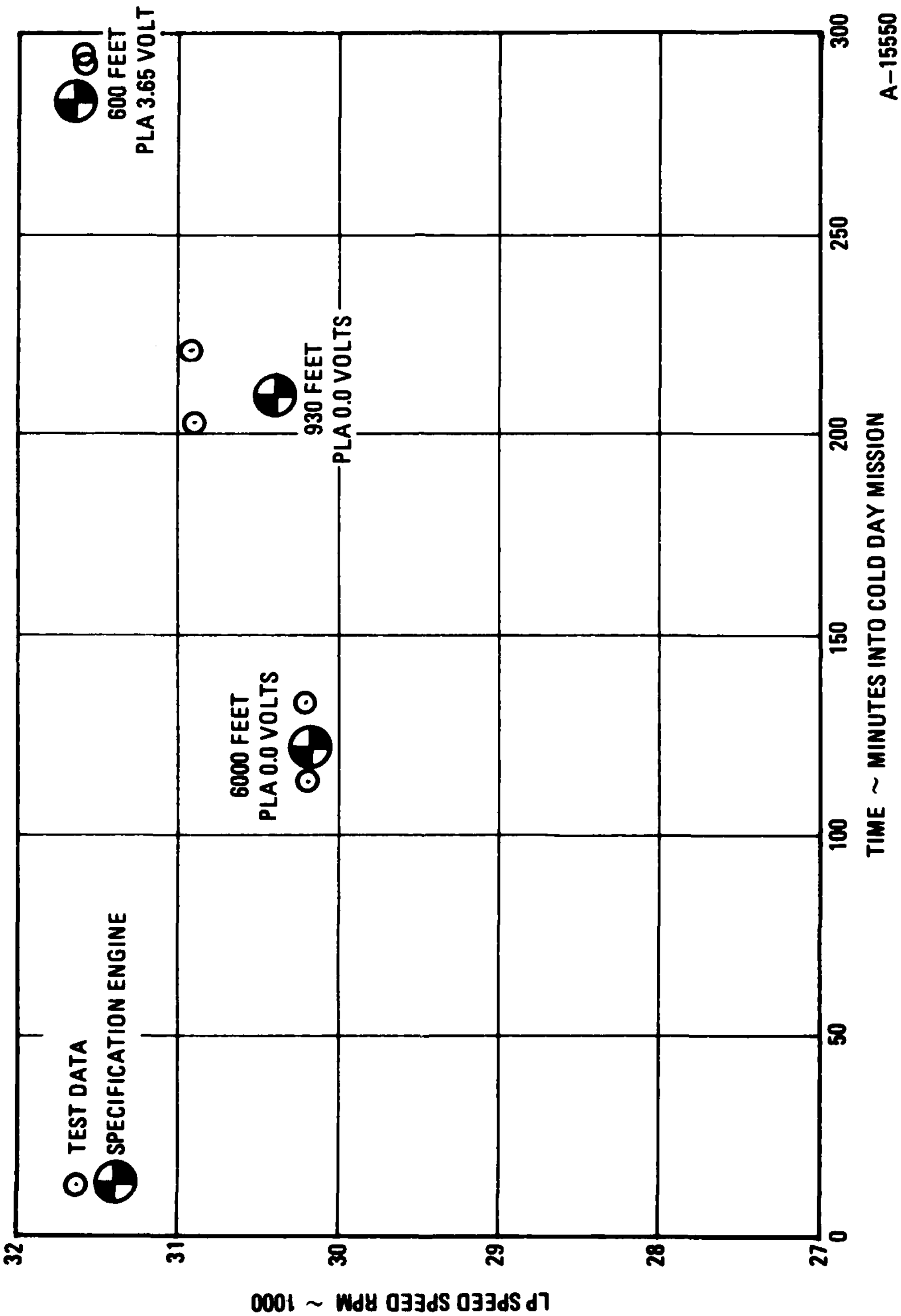


Figure 3-23. Engine 828/Build 6, Time History of LP Spool Speed, Cold Day Mission Simulation (Various Flight Conditions)

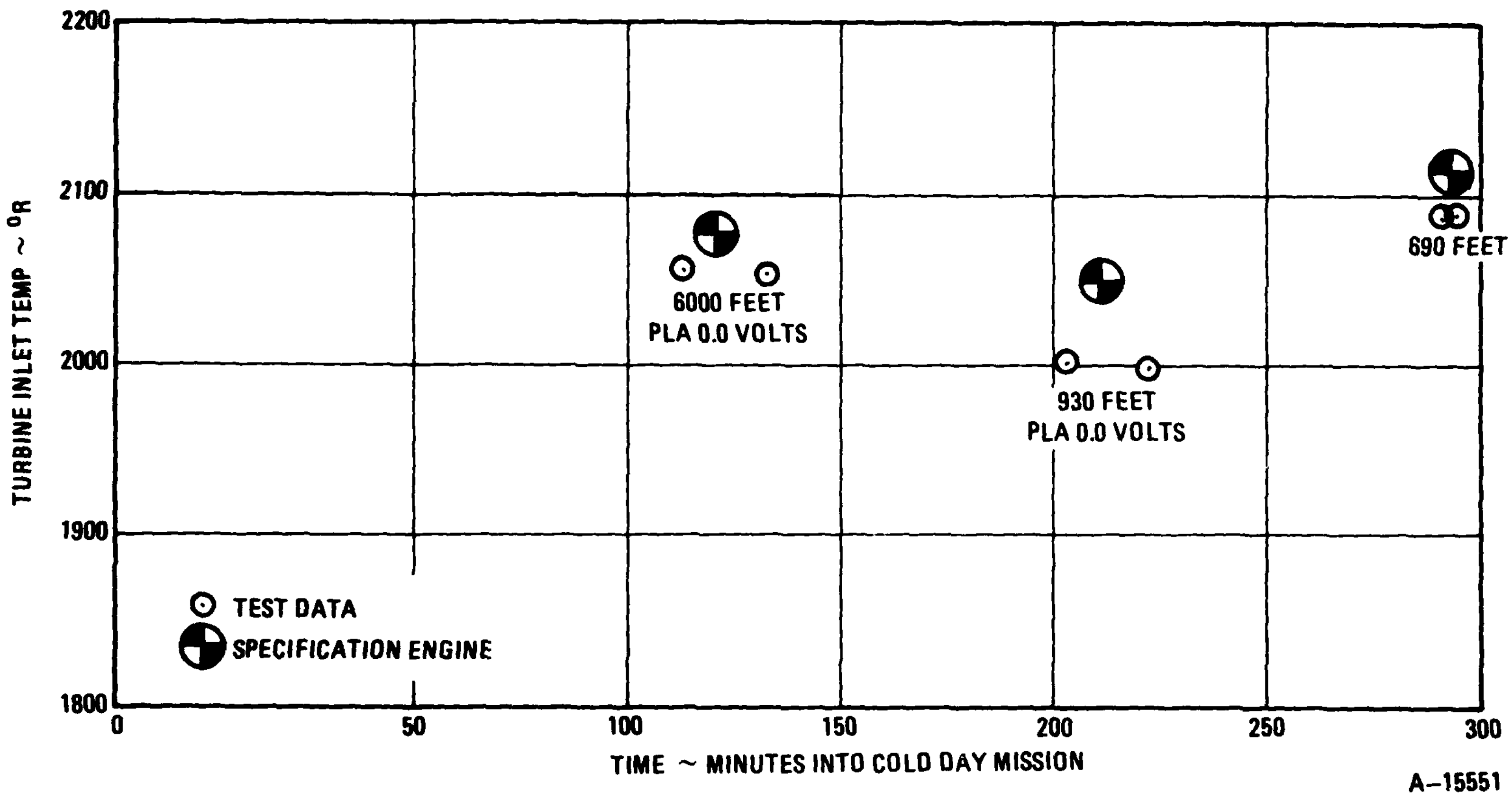


Figure 3-24. Engine 828/Build 6, Time History of Turbine Inlet Temperature, Cold Day Mission Simulation (Various Flight Conditions)

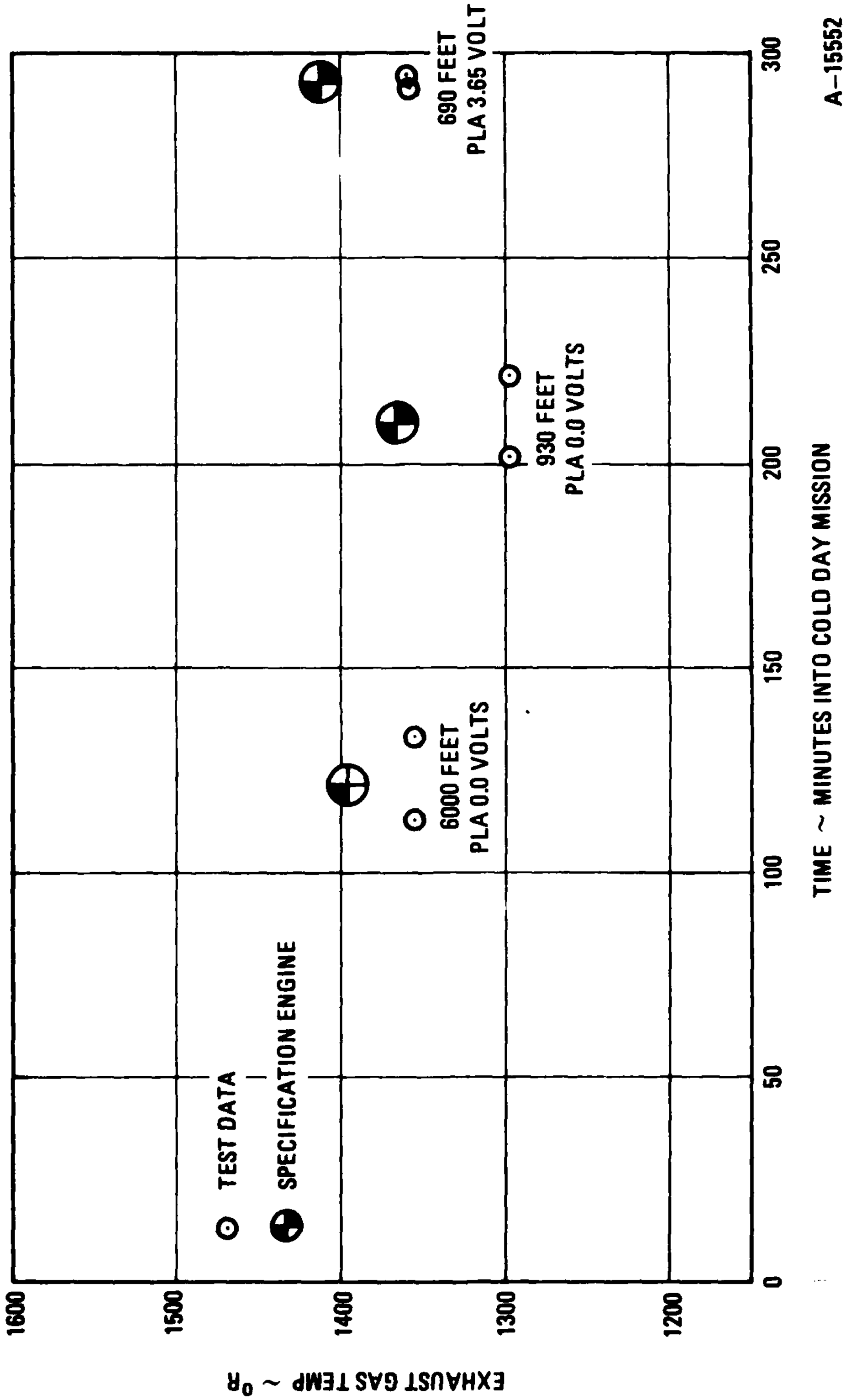


Figure 3-25. Engine 828/Build 6, Time History of Exhaust Gas Temperature, Cold Day Mission Simulation (Various Flight Conditions)

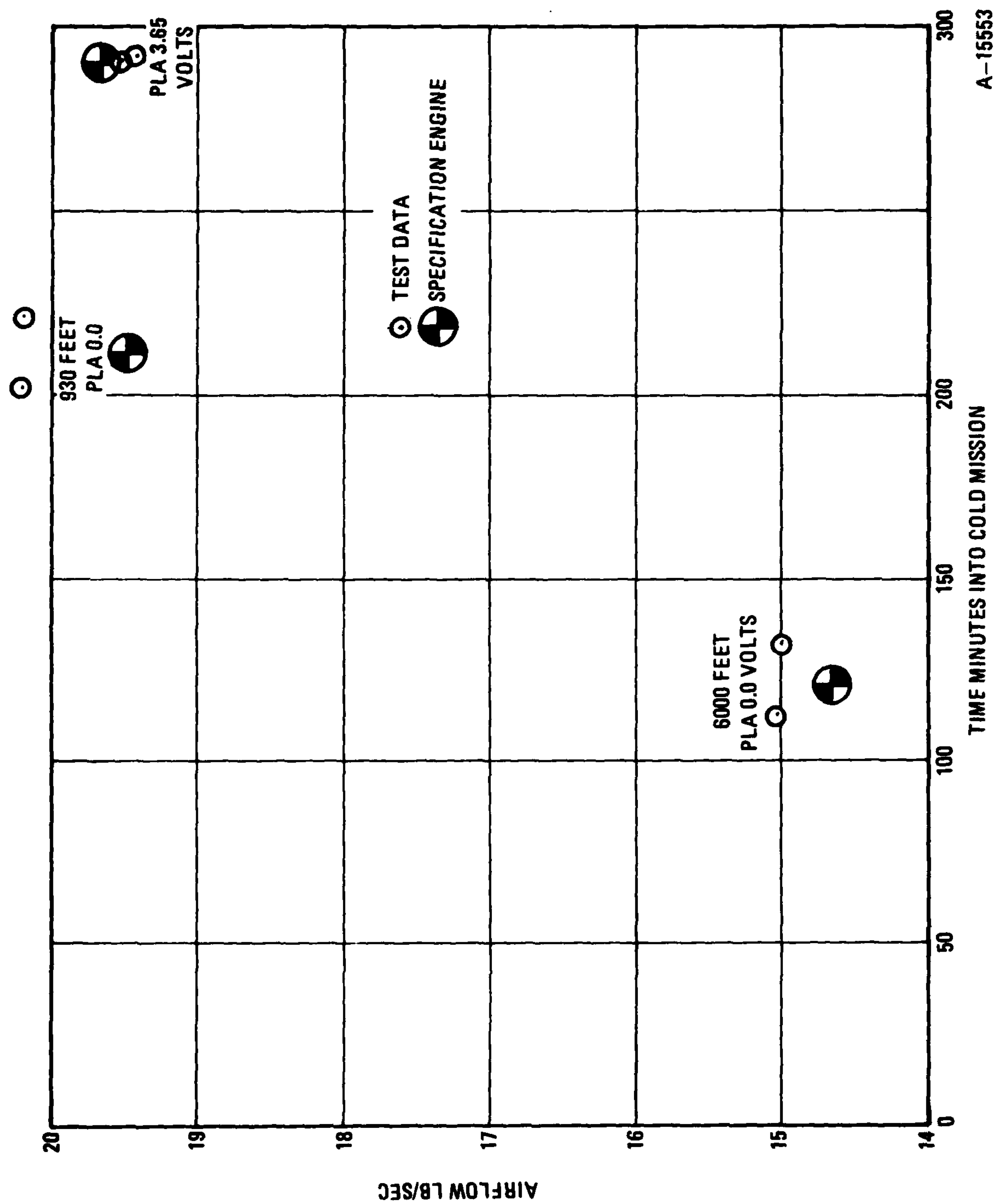


Figure 3-26. Engine 828/Build 6, Time History of Engine Airflow, Cold Day Mission Simulation (Various Flight Conditions)

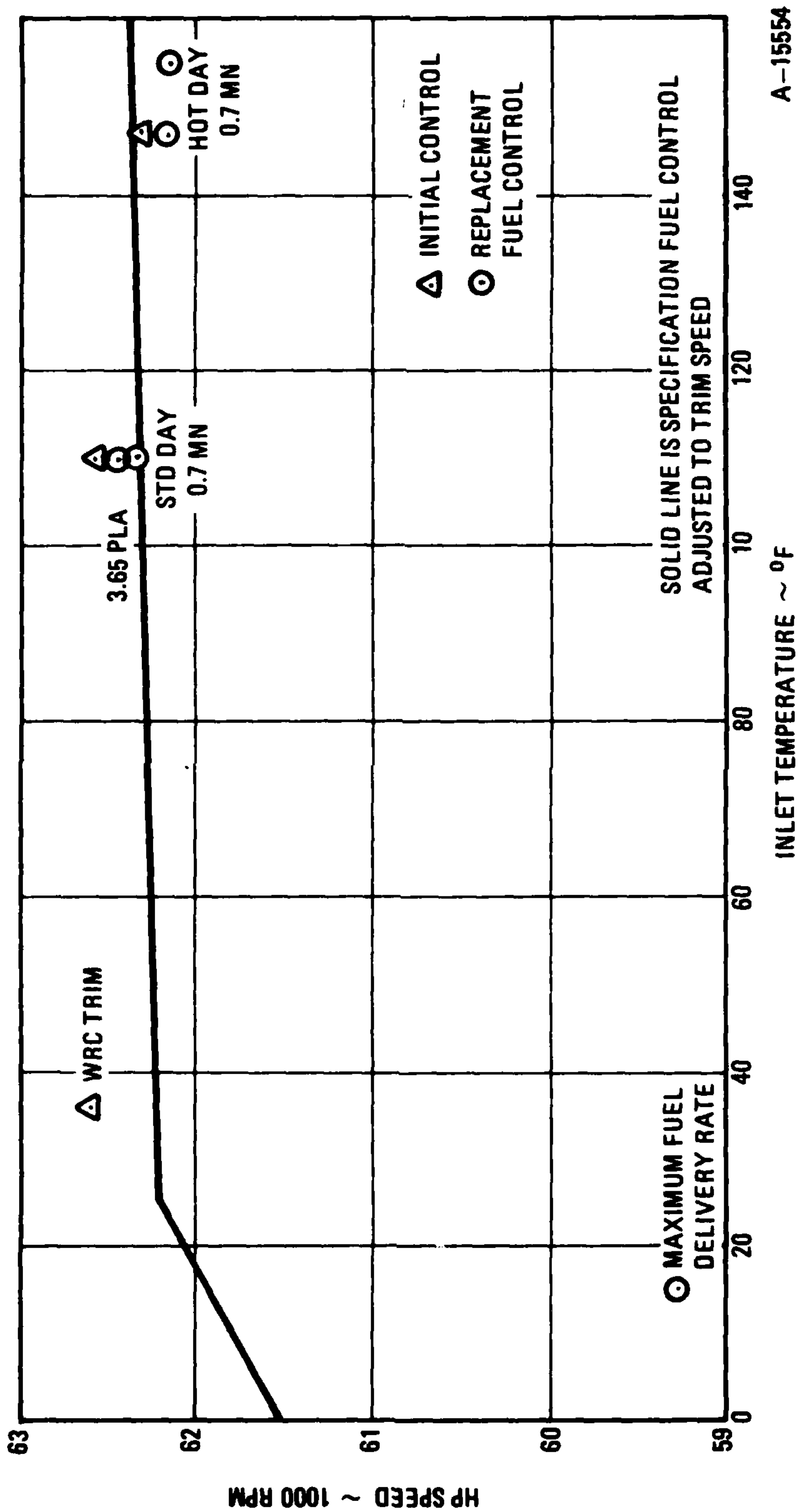


Figure 3-27. Engine 828/Build 6, HP Governed Speed as a Function of Inlet Air Temperature

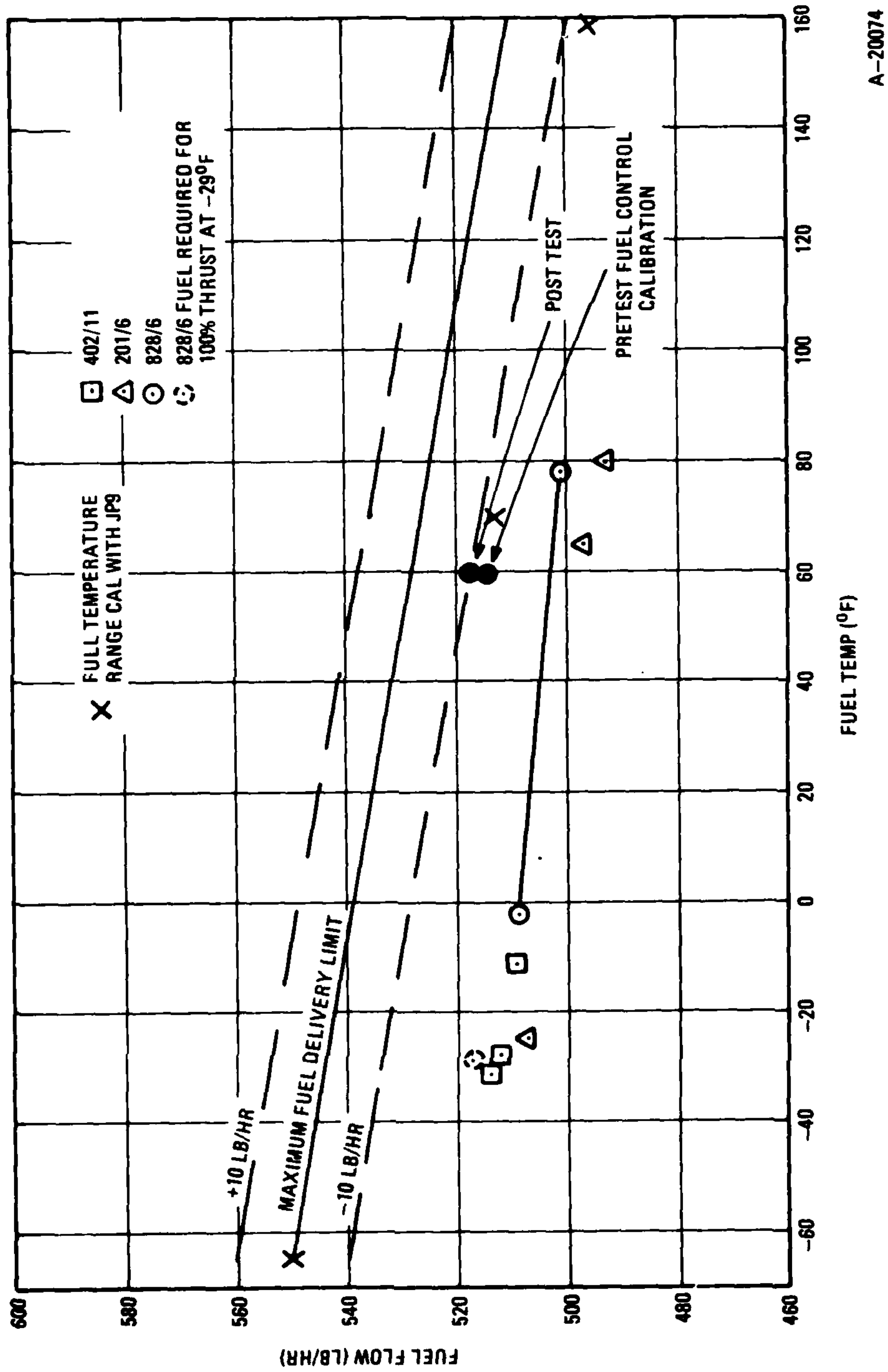


Figure 3-28. Engine 828/Build 6, Fuel Demand as a Function of Engine Inlet Air Temperature (Including Comparison with Data Obtained From Other Qualification Test Engines)

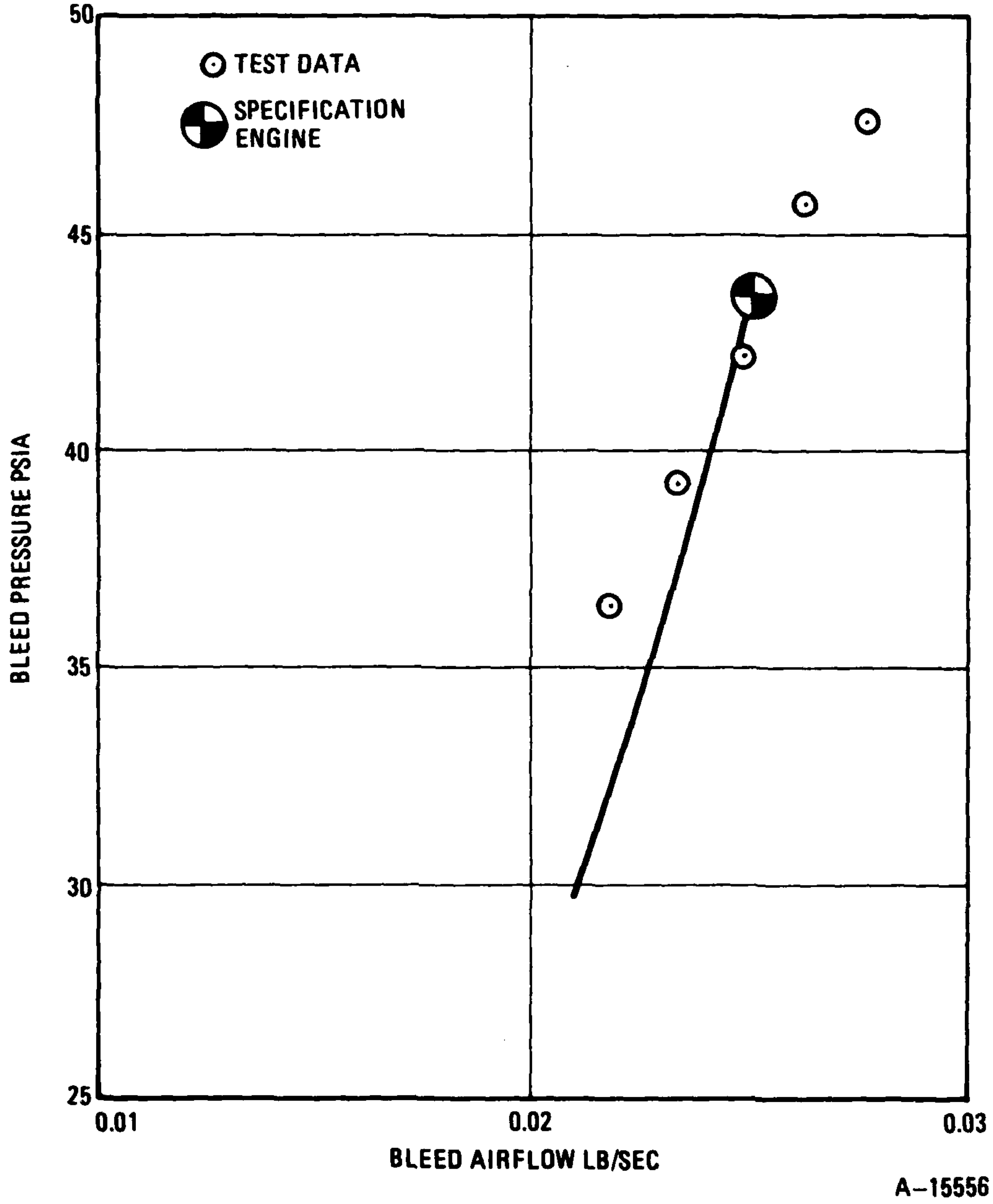


Figure 3-29. Engine 828/Build 6, Bleed Air System Performance, AEDC Performance Calibration Data

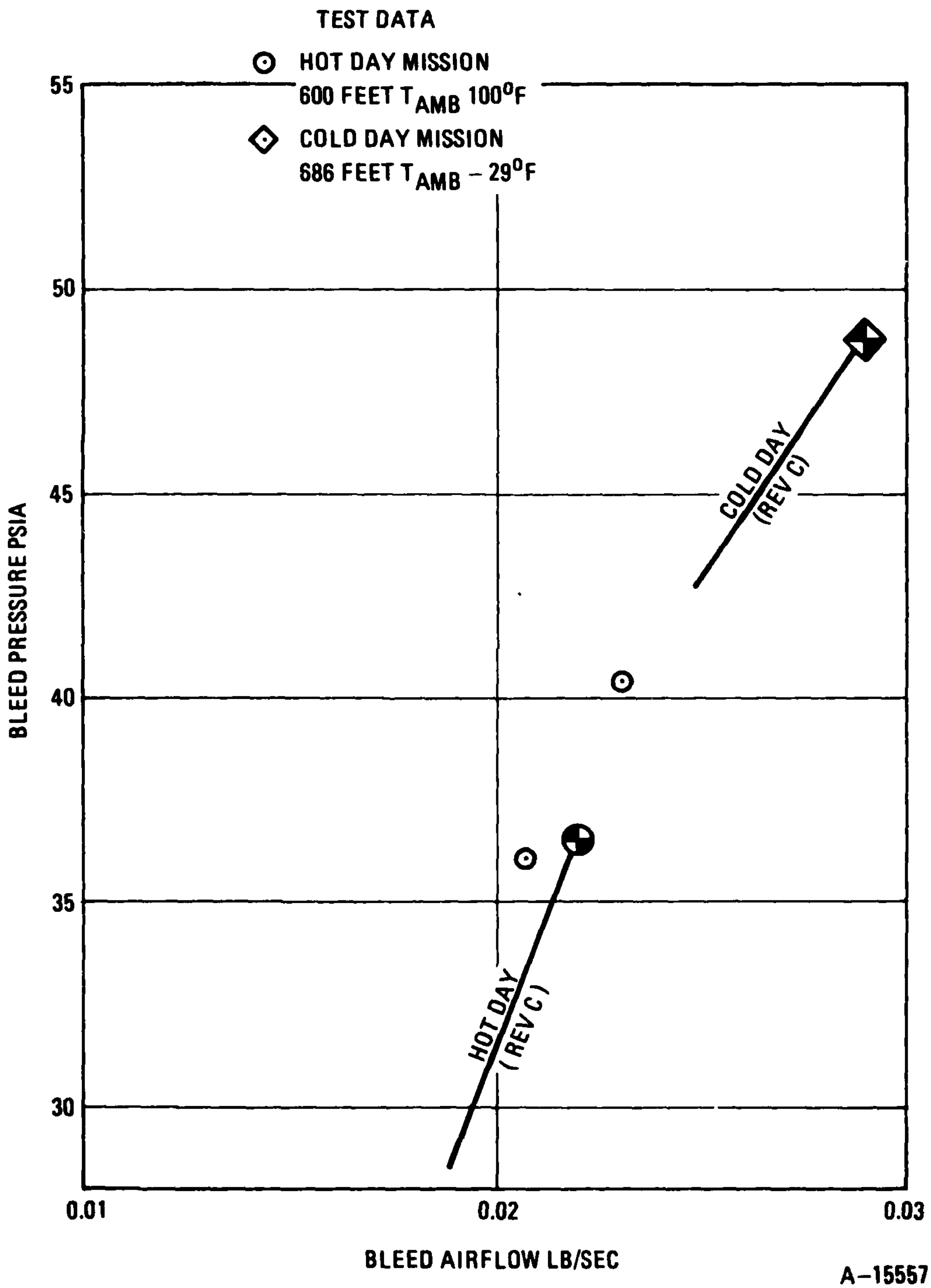


Figure 3-30. Engine 828/Build 6, Bleed Air System Performance, Hot and Cold Day Mission Simulation Data

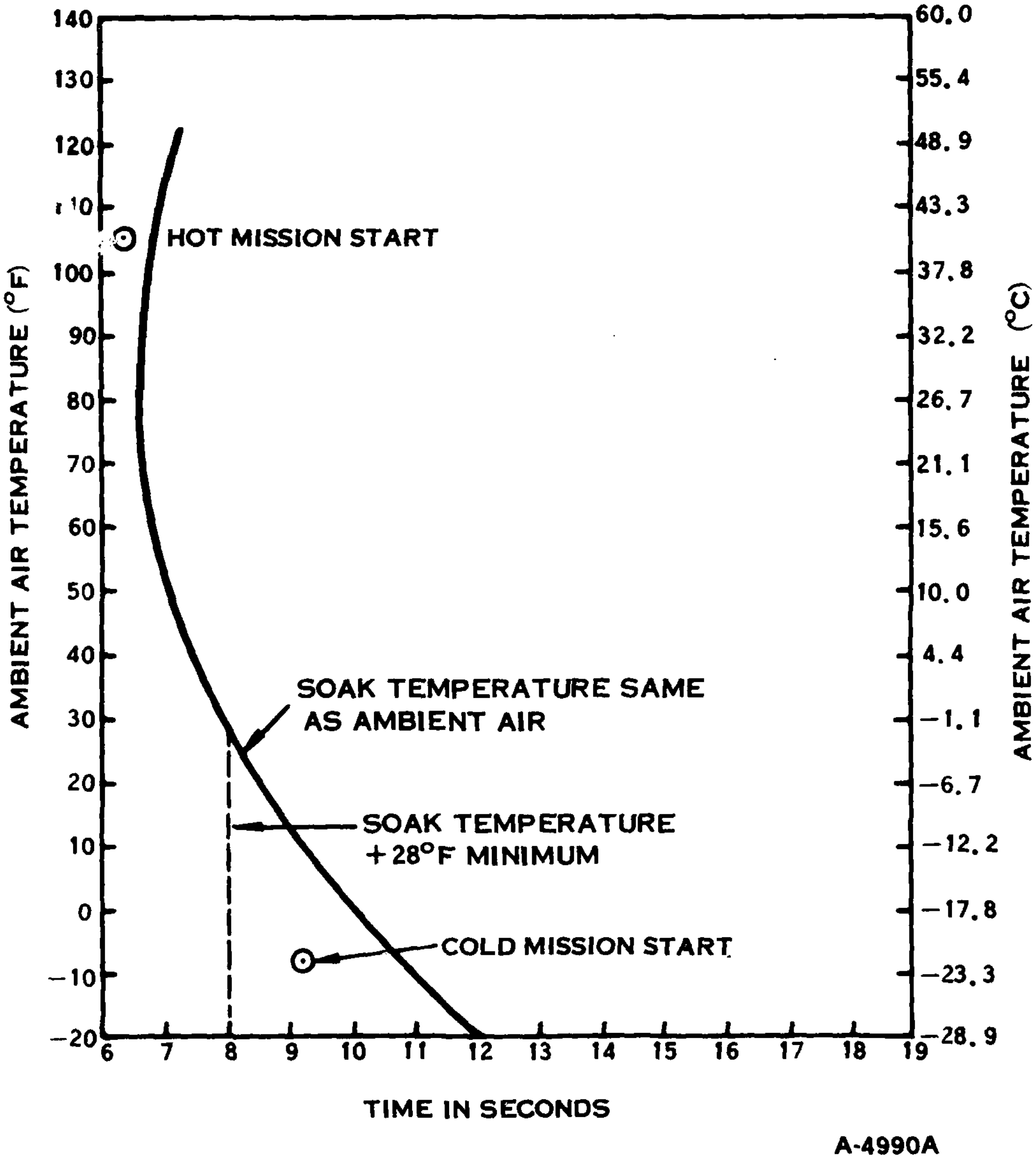


Figure 3-31. Engine 828/Build 6, Cartridge Start Times as Compared to Ambient Temperatures, Hot and Cold Day Mission Simulation Tests

AD-A102 257 WILLIAMS RESEARCH CORP WALLED LAKE MI F/G 21/5
CRUISE MISSILE ENGINE PROGRAM CONTRACT DATA REQUIREMENTS LIST S--ETC(U)
JUN 81 L TOOT N00019-78-C-0206
UNCLASSIFIED WRC-79-106-39 NL

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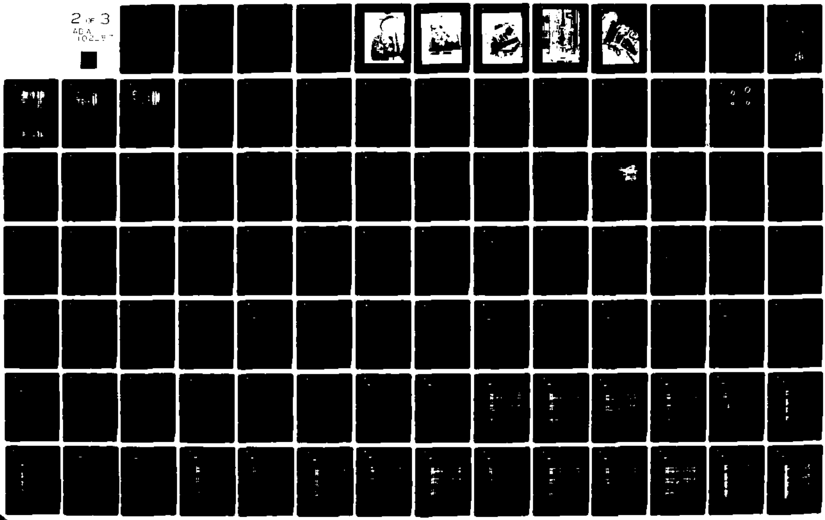


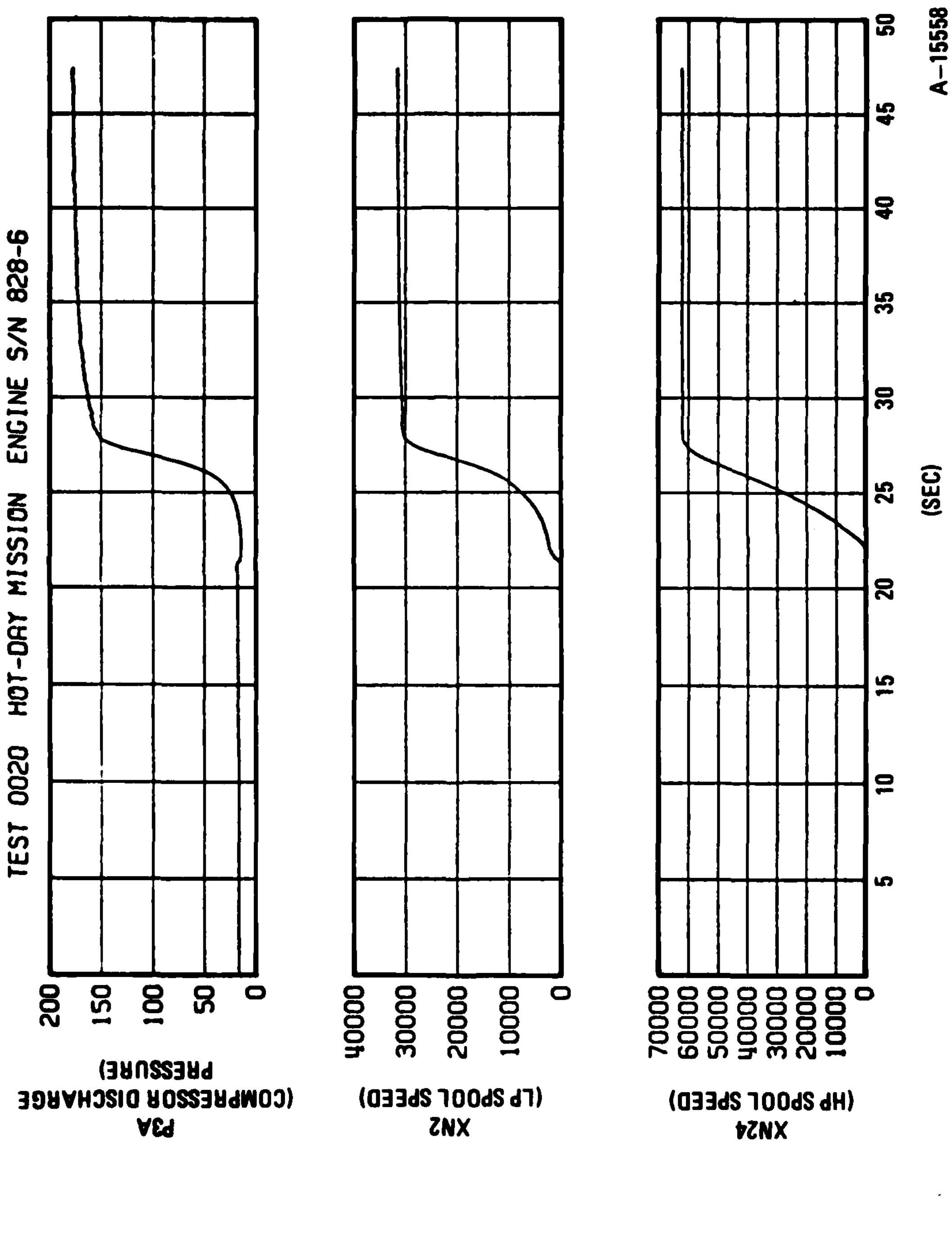


Figure 3-32. Engine 828/Build 6, Time Histories of Compressor Discharge Pressure, LP Spool Speed and HP Spool Speed, Hot Day Mission Simulation Cartridge Start

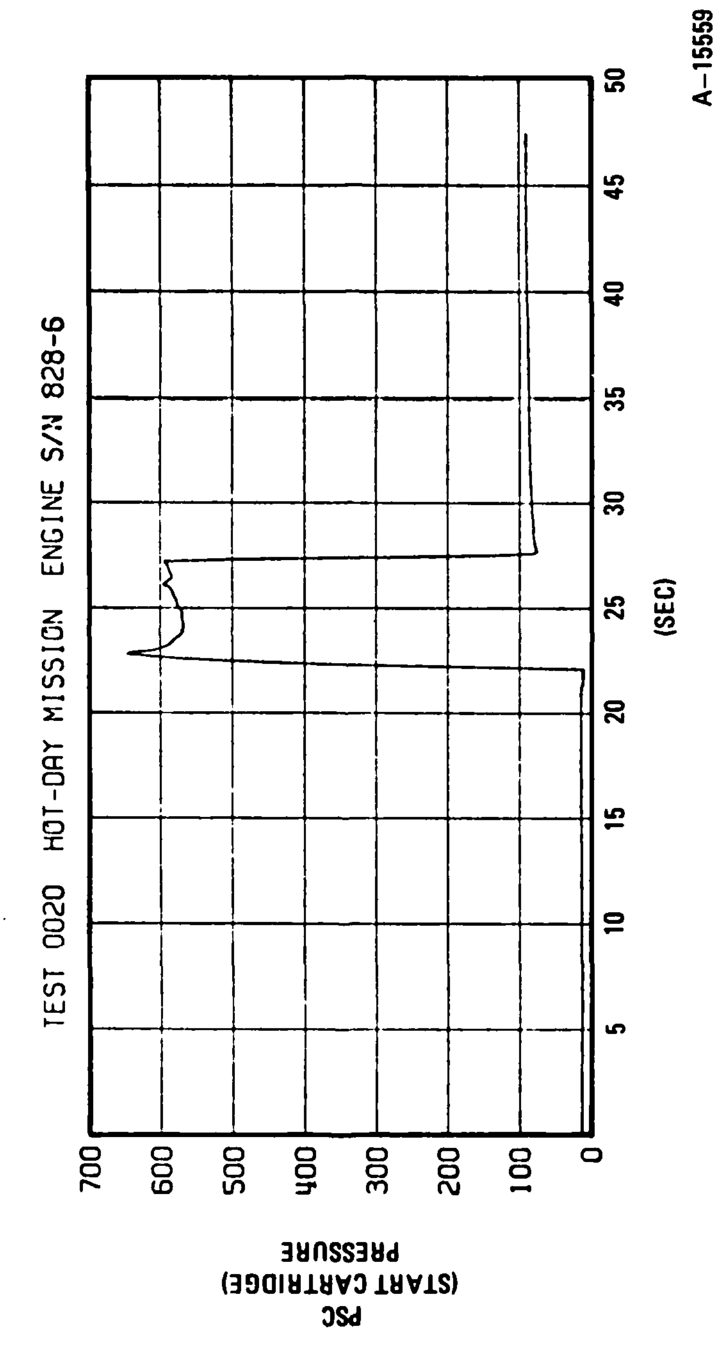


Figure 3-33. Engine 828/Build 6, Time History of Start Cartridge Pressure, Hot Day Mission Simulation Cartridge Start

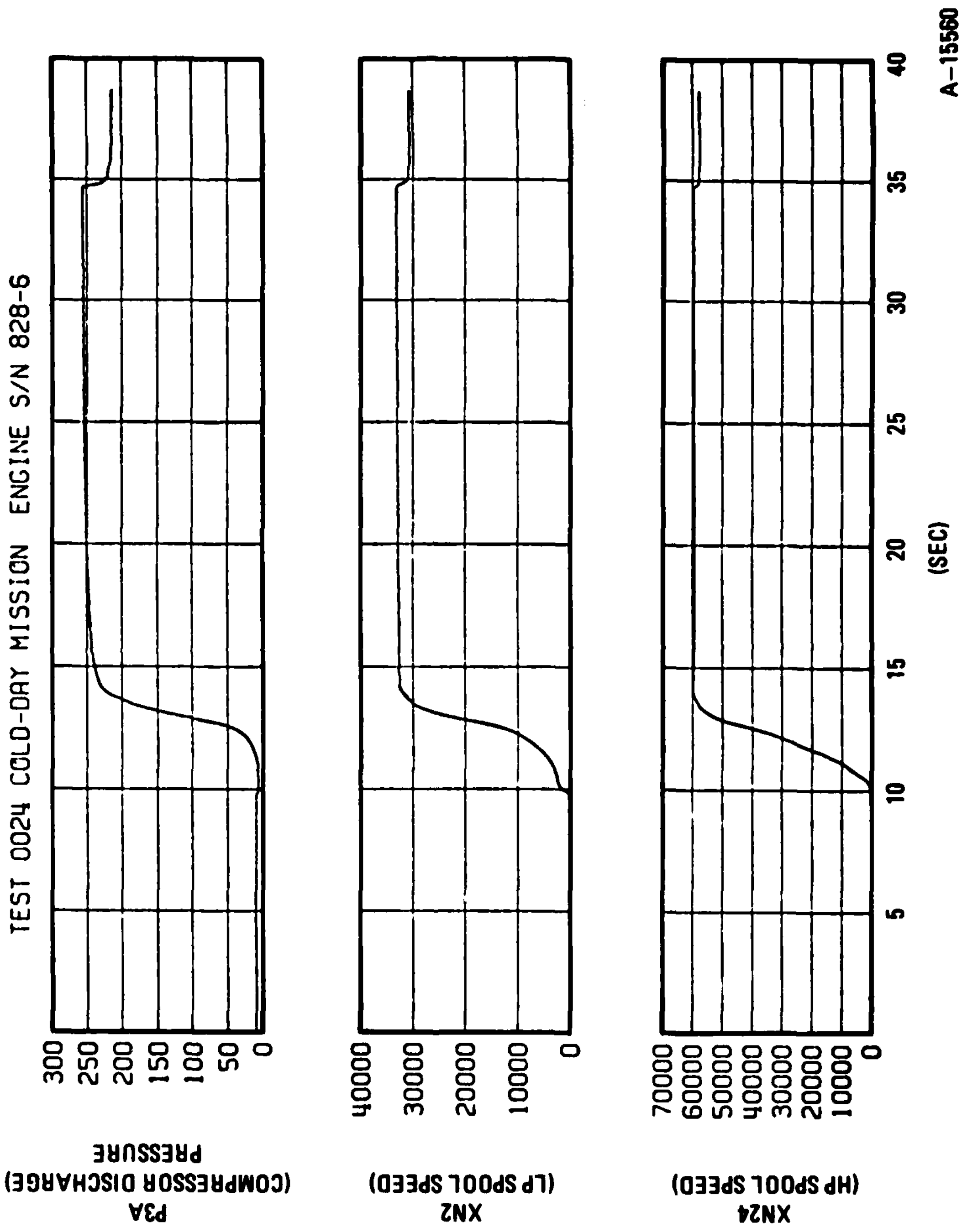


Figure 3-34. Engine 828/Build 6, Time History of Compressor Discharge Pressure, LP Spool Speed and HP Spool Speed, Cold Day Mission Simulation Cartridge Start

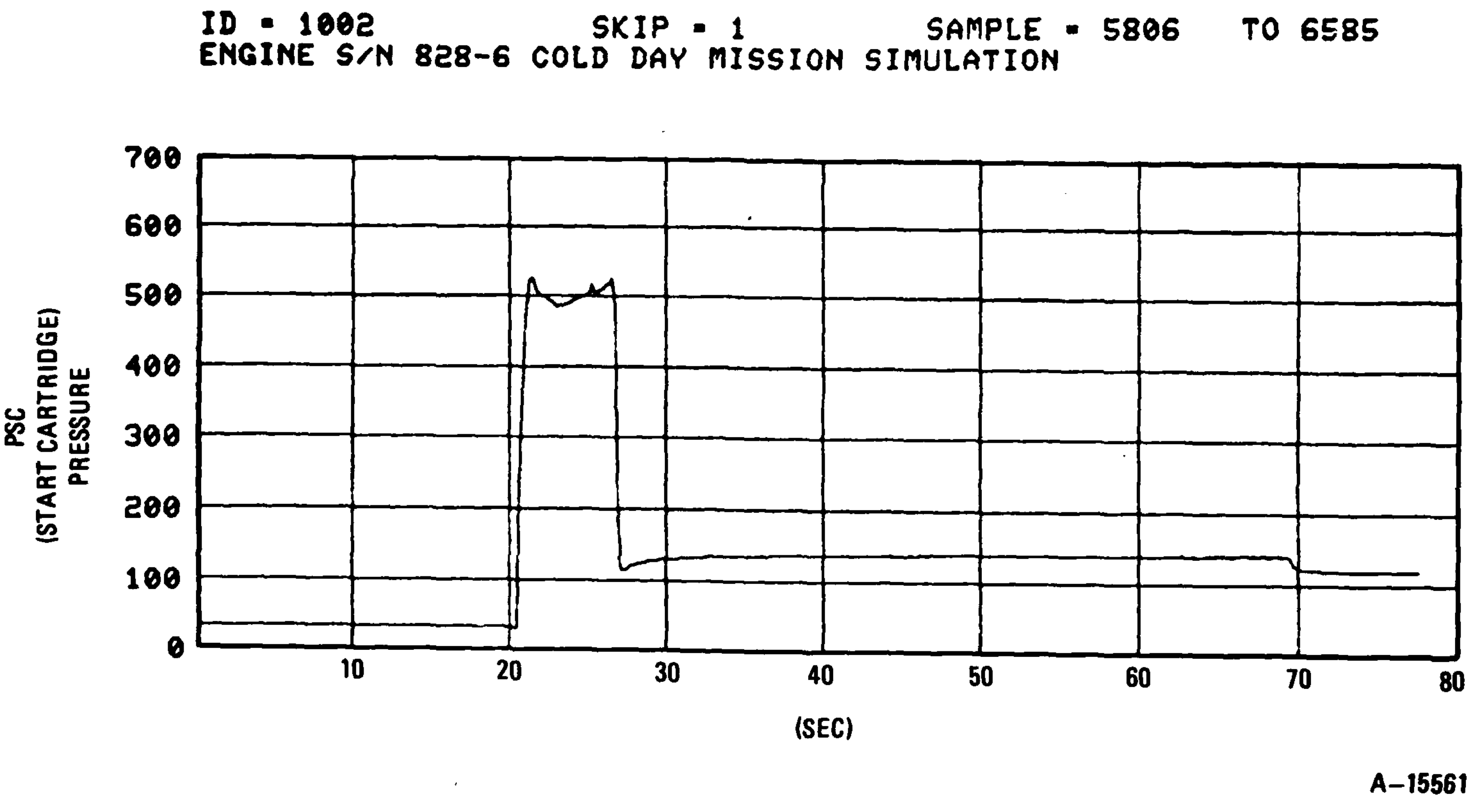


Figure 3-35. Engine 828/Build 6, Time History of Start Cartridge Pressure, Cold Day Mission Simulation Cartridge Start

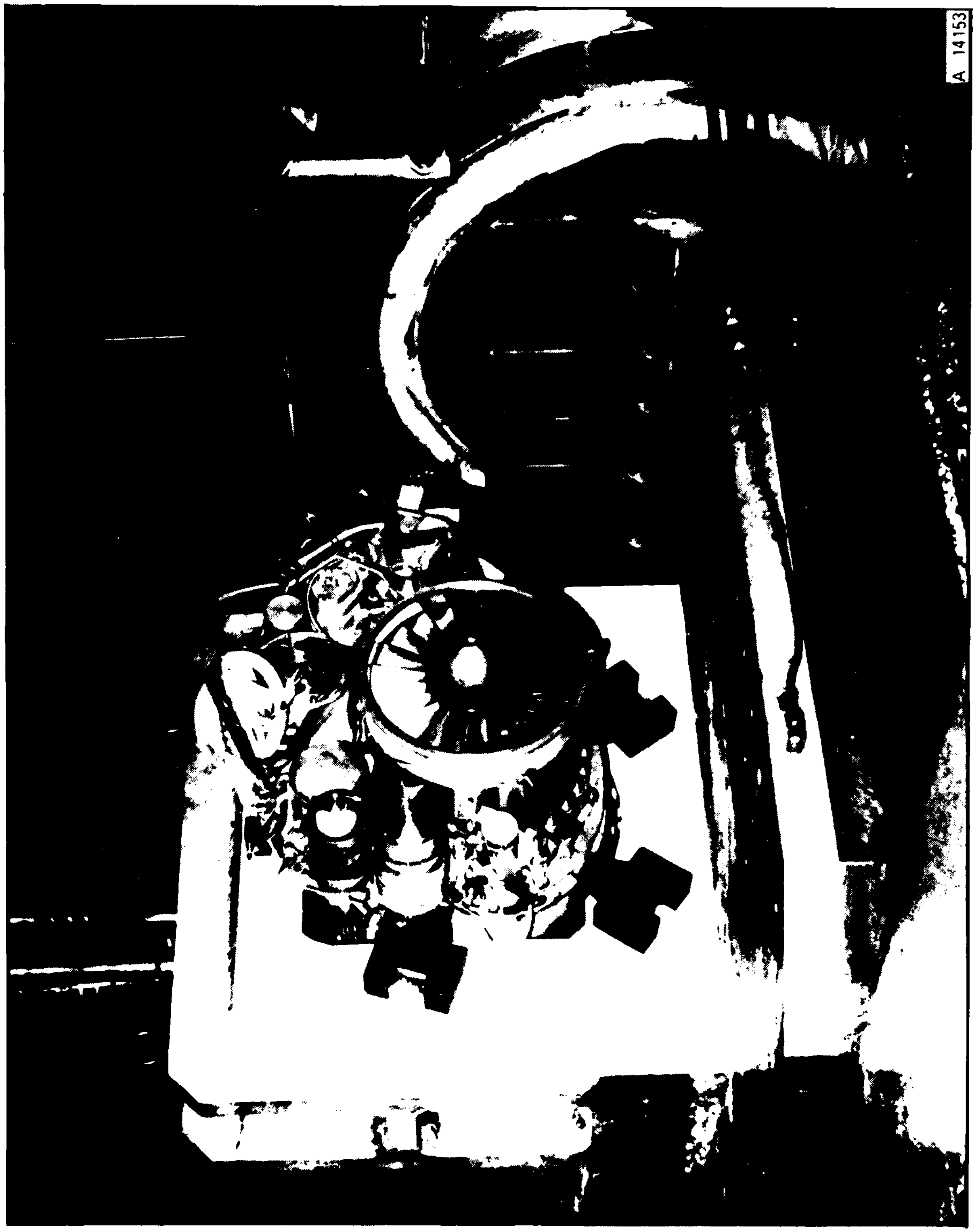


Figure 3-36. Typical F107 Engine Installation in Test Fixture at Bendix Aerospace, Ann Arbor (Overall View)

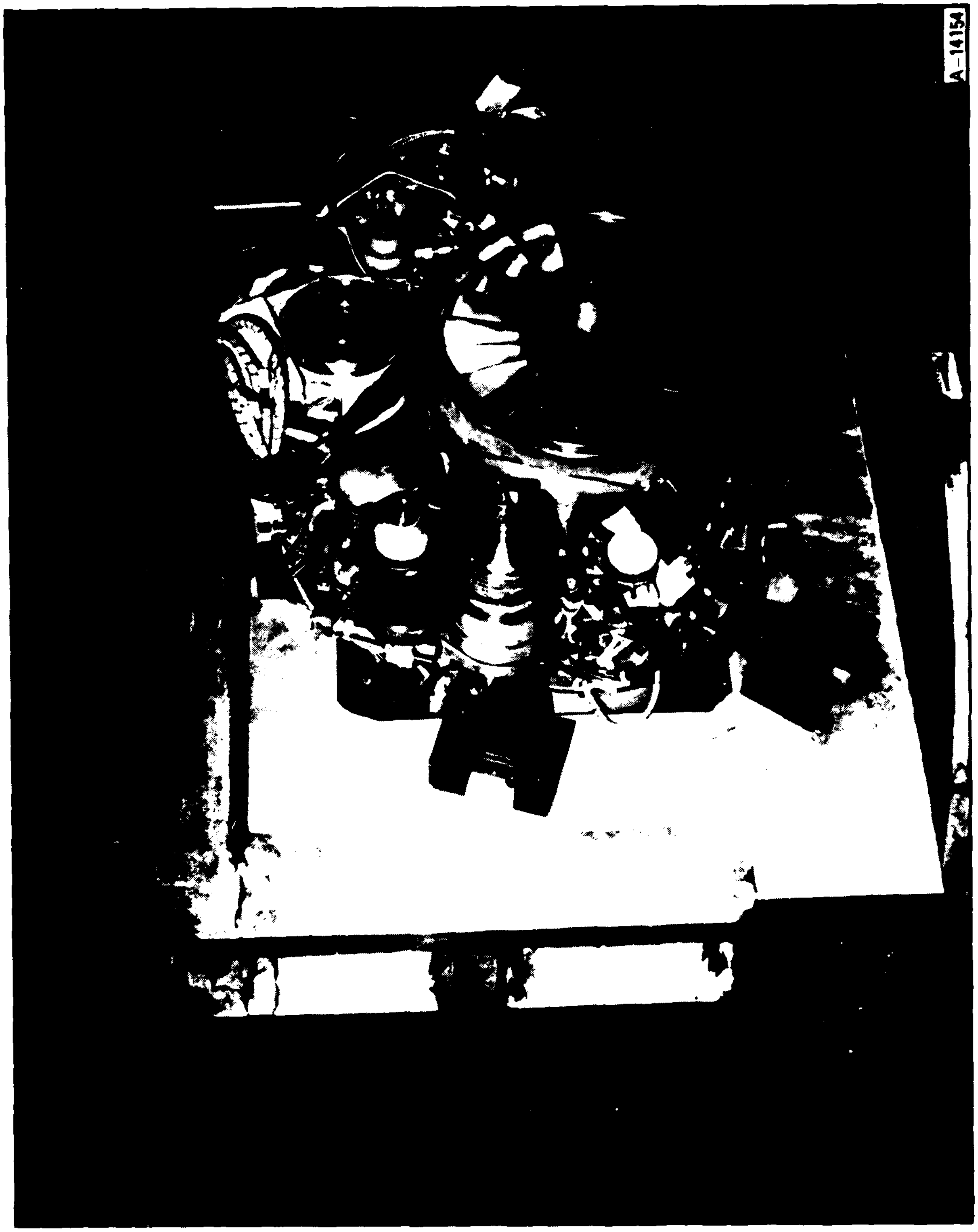


Figure 3-37. Typical F107 Engine Installation in Vibration Test Fixture (Front View)

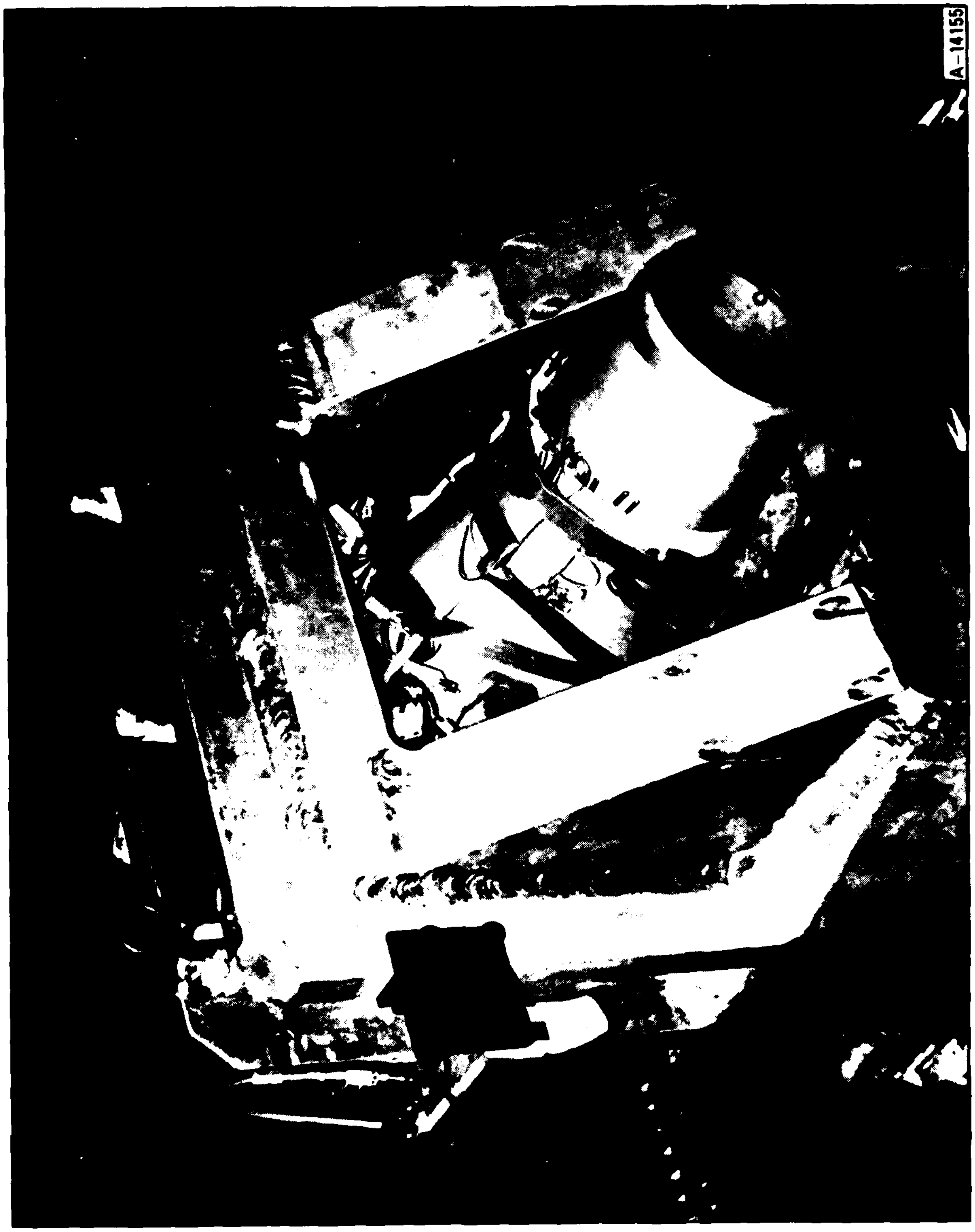


Figure 3-38. Typical F107 Engine Installation in Vibration Test Fixture (Rear View)

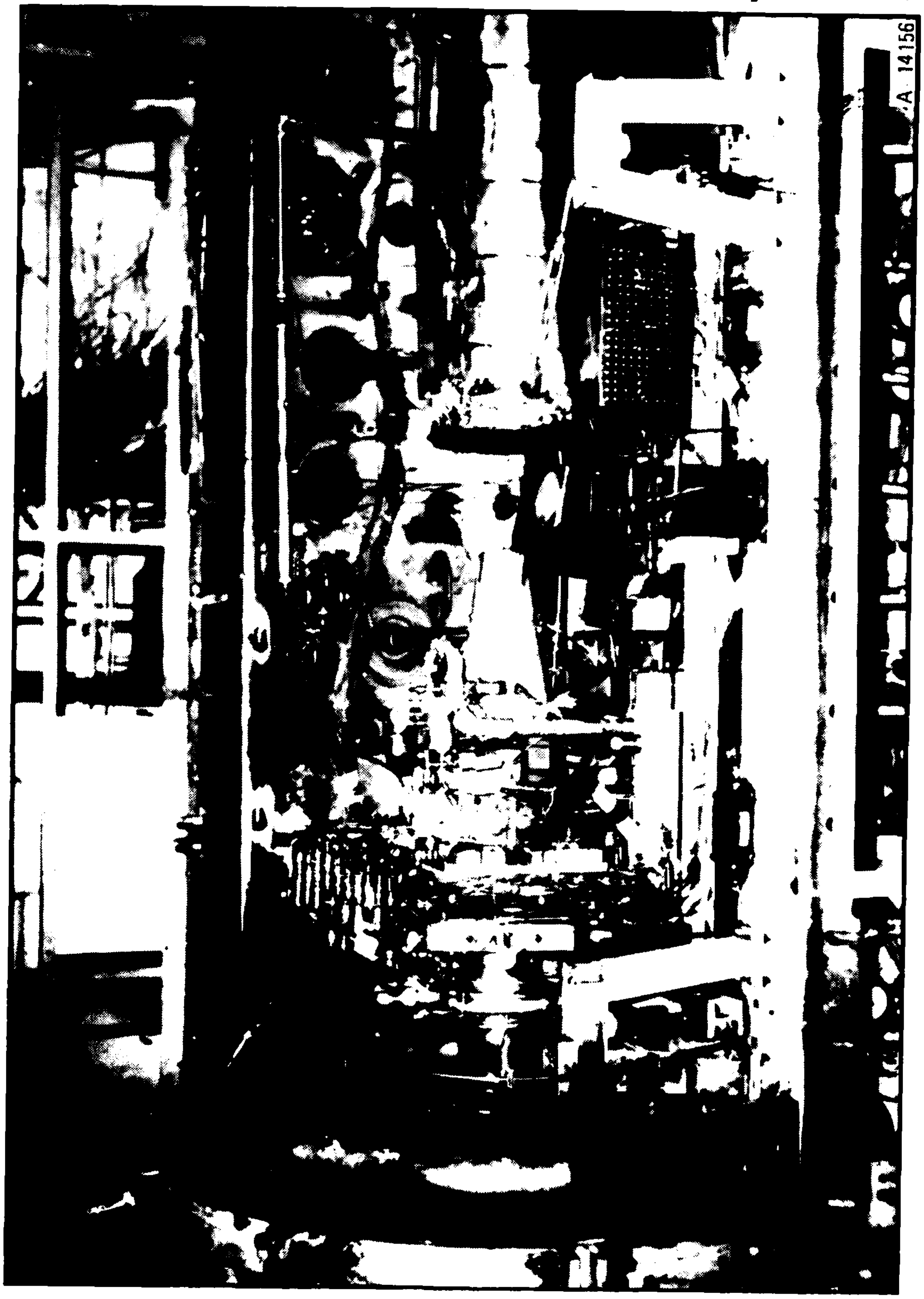
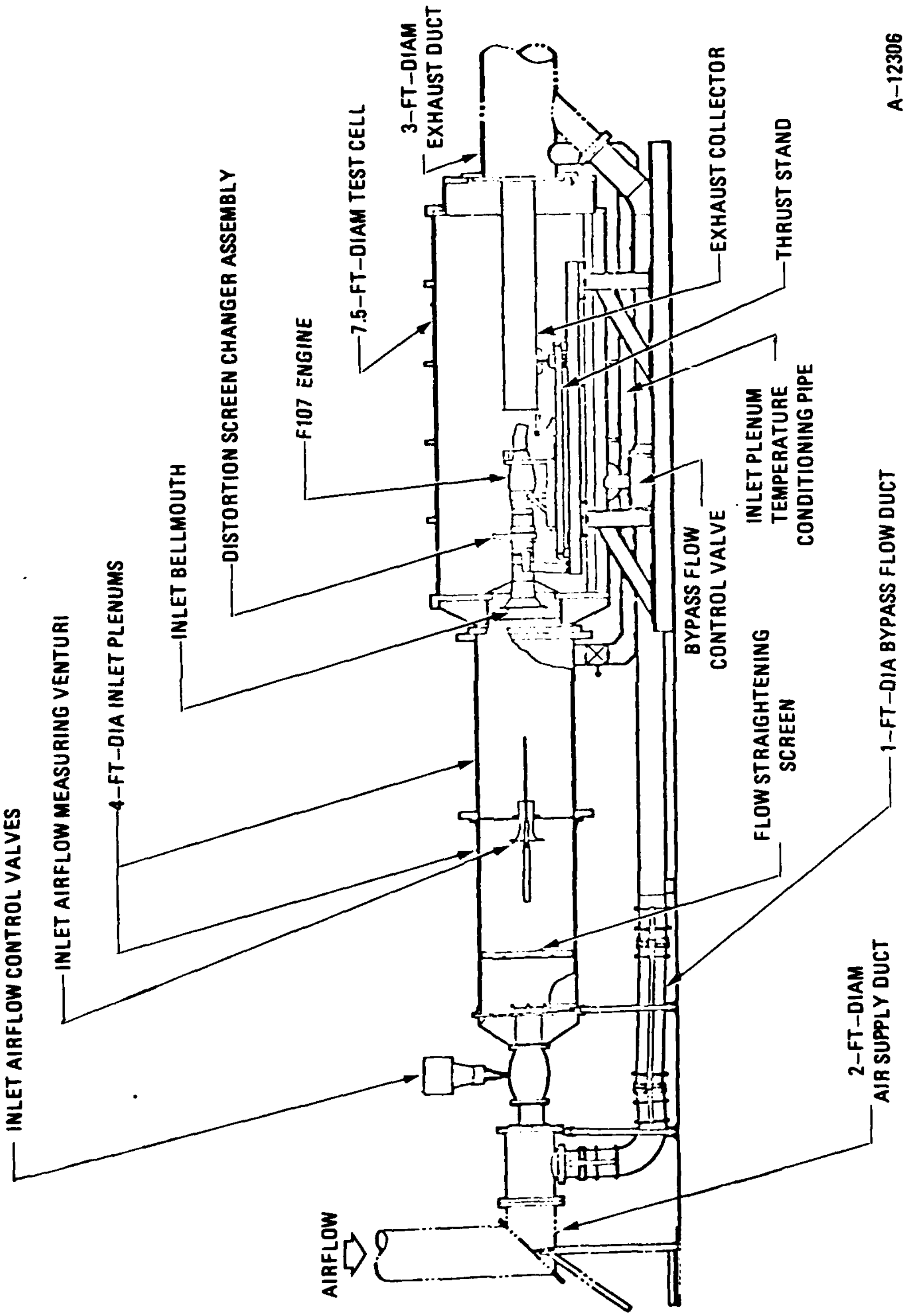


Figure 3-39. Typical F107 Engine Installation in Test Cell T-5 at AEDC (Overview)

Figure 3-40. Typical F107 Engine Installation in Test Cell T-5 at AEDC (Closeup)



A. PROPULSION DEVELOPMENT TEST CELL T-5

Figure 3-41. Elevation Drawing of Test Cell T-5 at AEDC

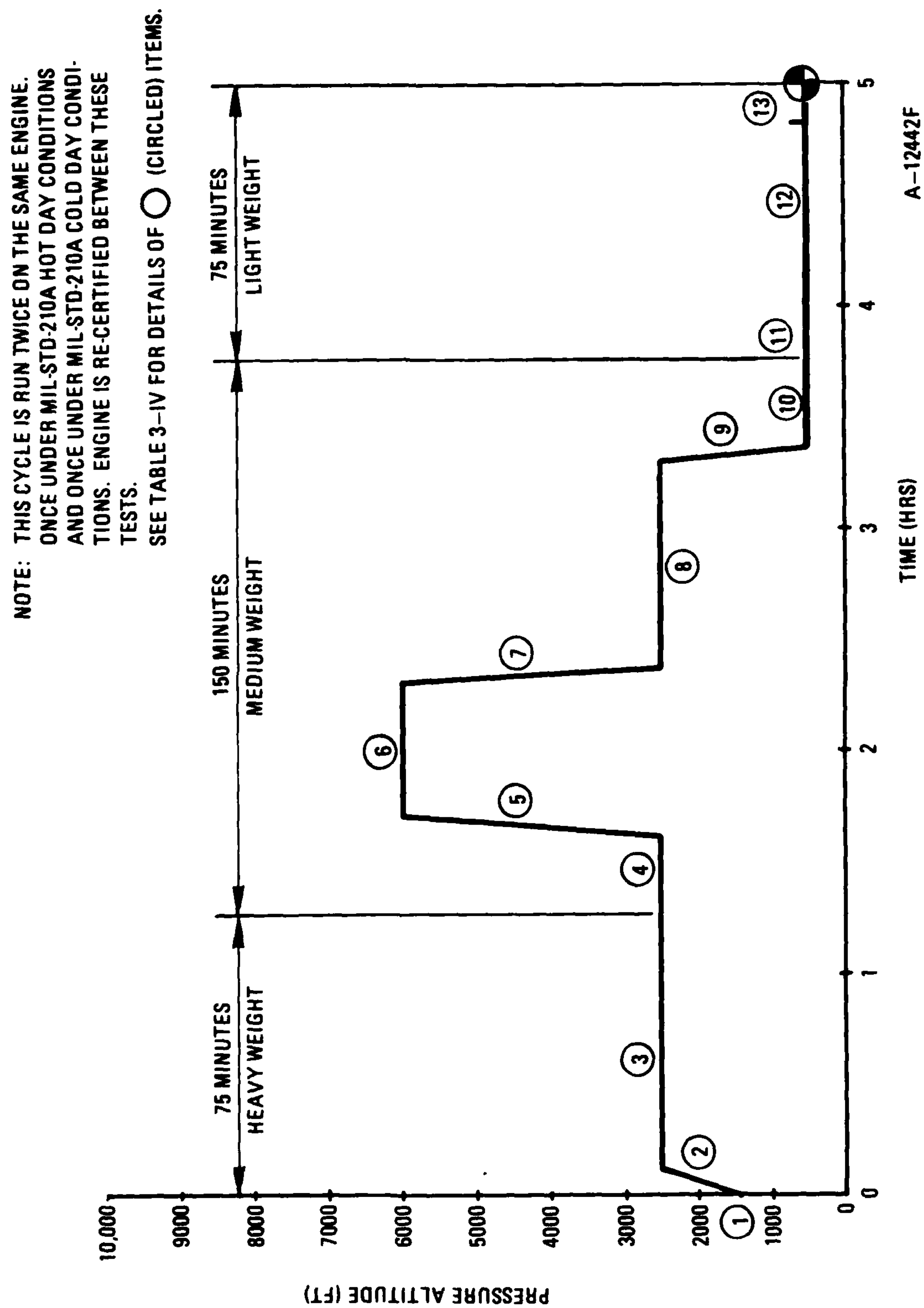


Figure 3-42. Basic Mission Simulation Profile

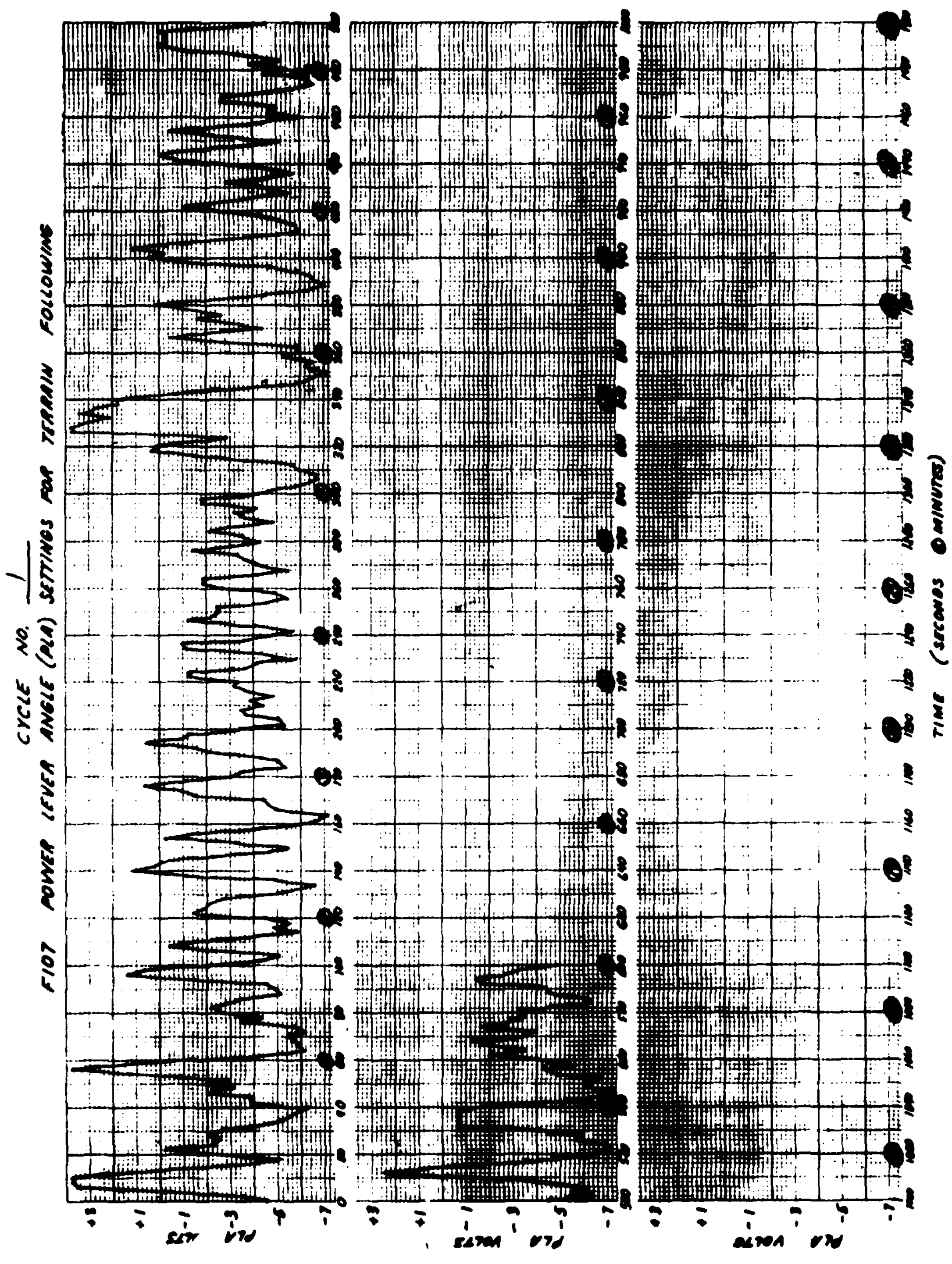


Figure 3-43. Graphic Presentation of PLA Settings for Terrain-Following Cycle No. 1

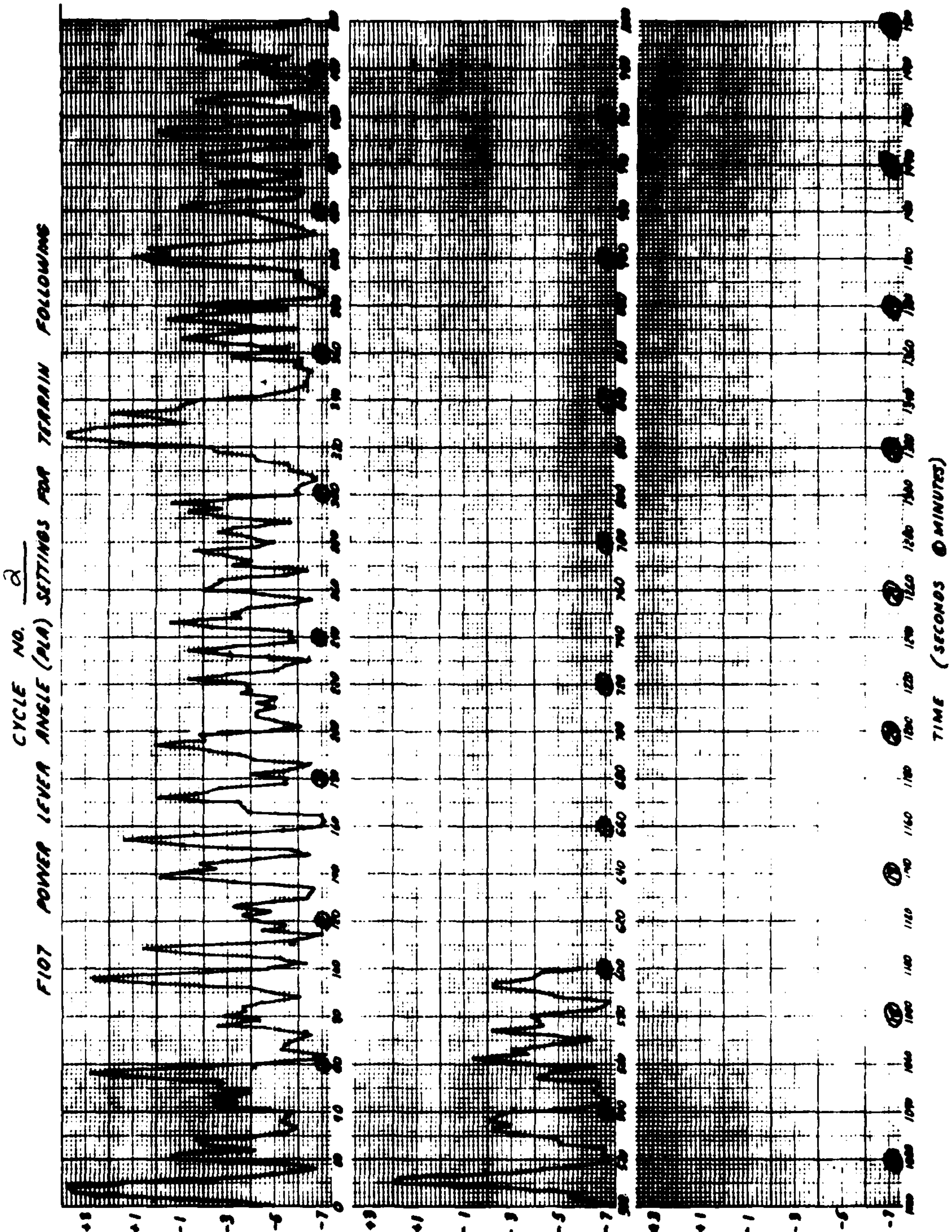


Figure 3-44. Graphic Presentation of PLA Settings for Terrain-Following Cycle No. 2

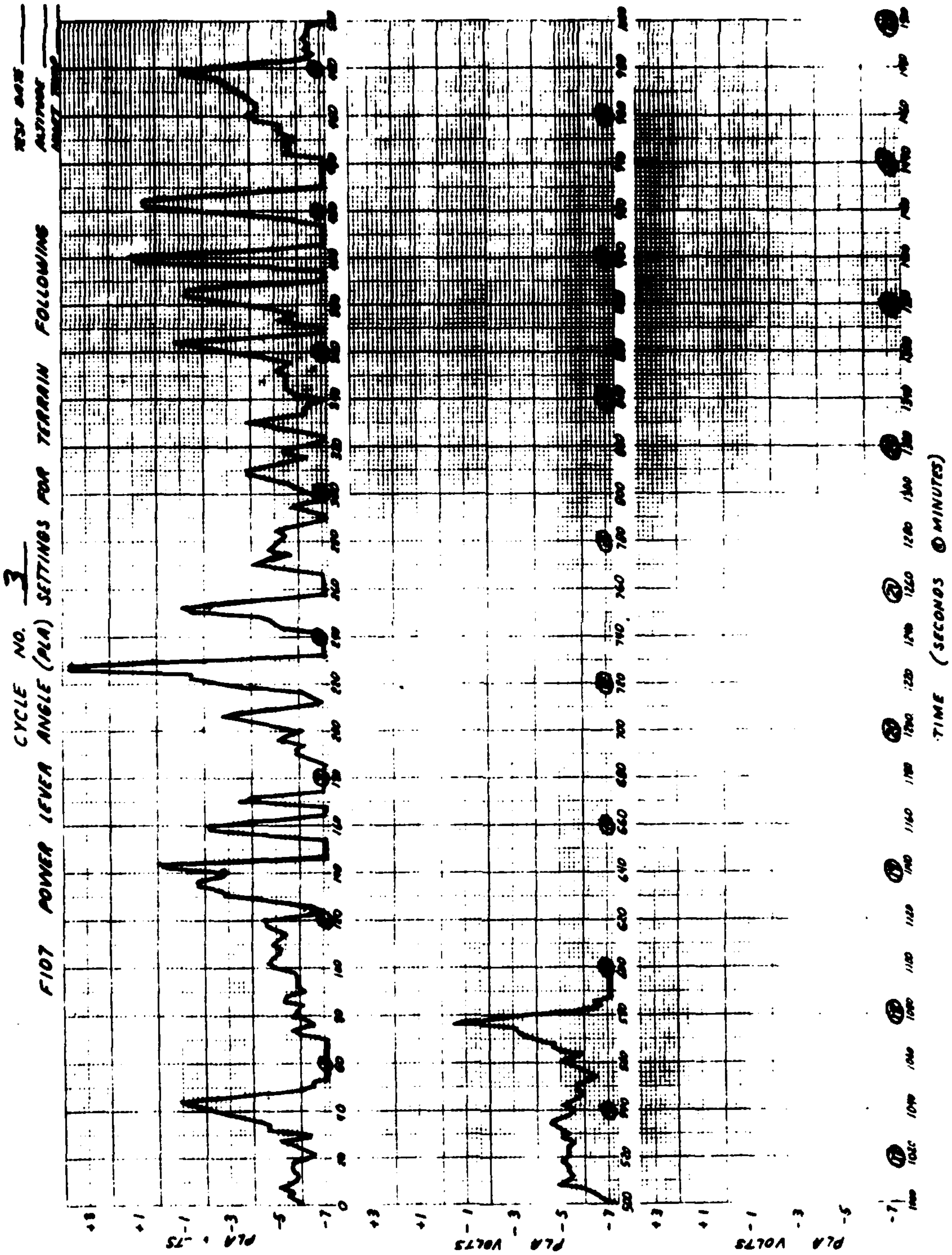


Figure 3-45. Graphic Presentation of PLA Settings for Terrain-Following Cycle No. 3

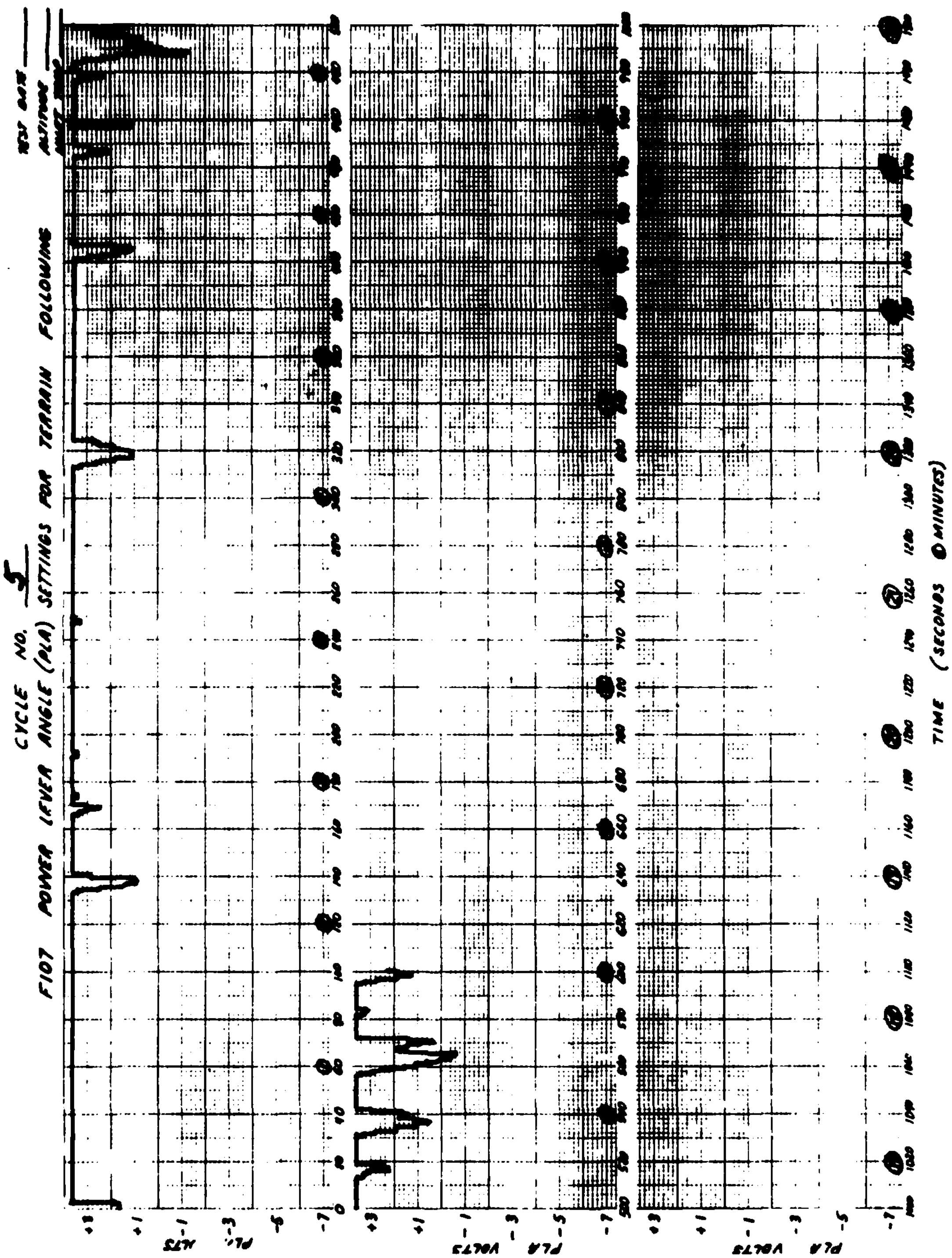


Figure 3-46. Graphic Presentation of PLA Settings for Terrain-Following Cycle No. 5

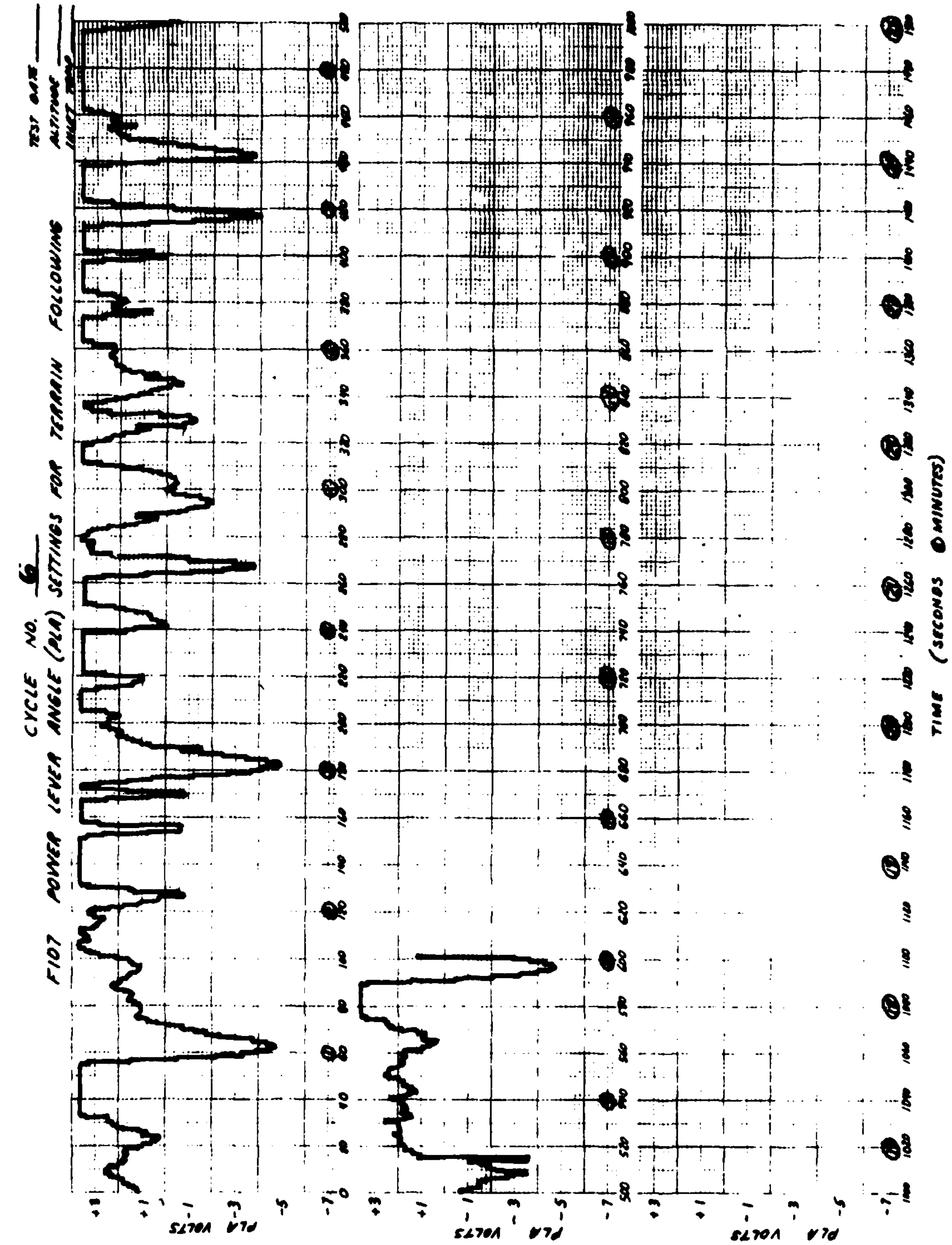
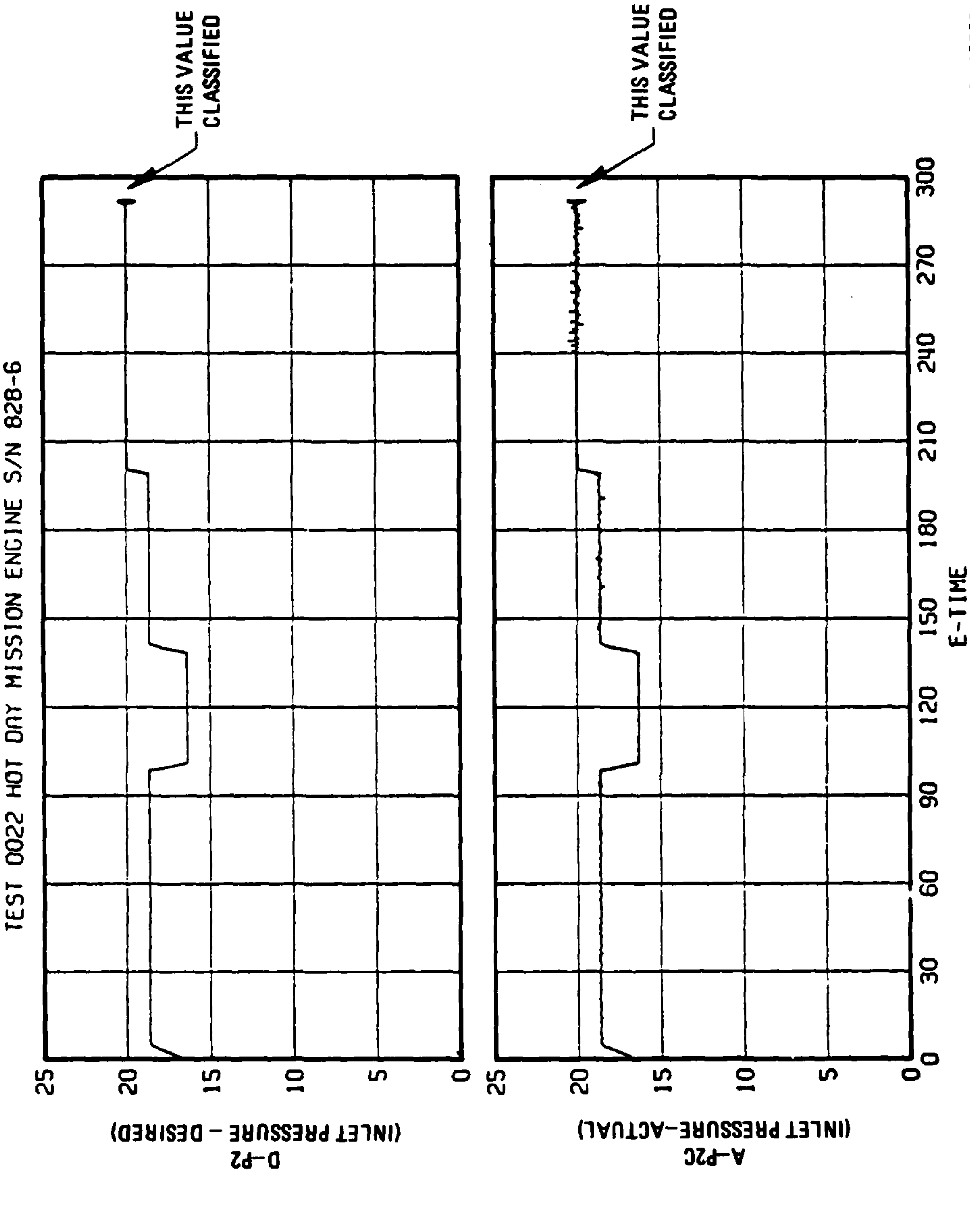


Figure 3-47. Graphic Presentation of PLA Settings for Terrain-Following Cycle No. 6



A-15562

Figure 3-48. Engine 828/Build 6, Time History of Inlet Pressure (Specification Compared to Actual Values), Hot Day Mission Simulation

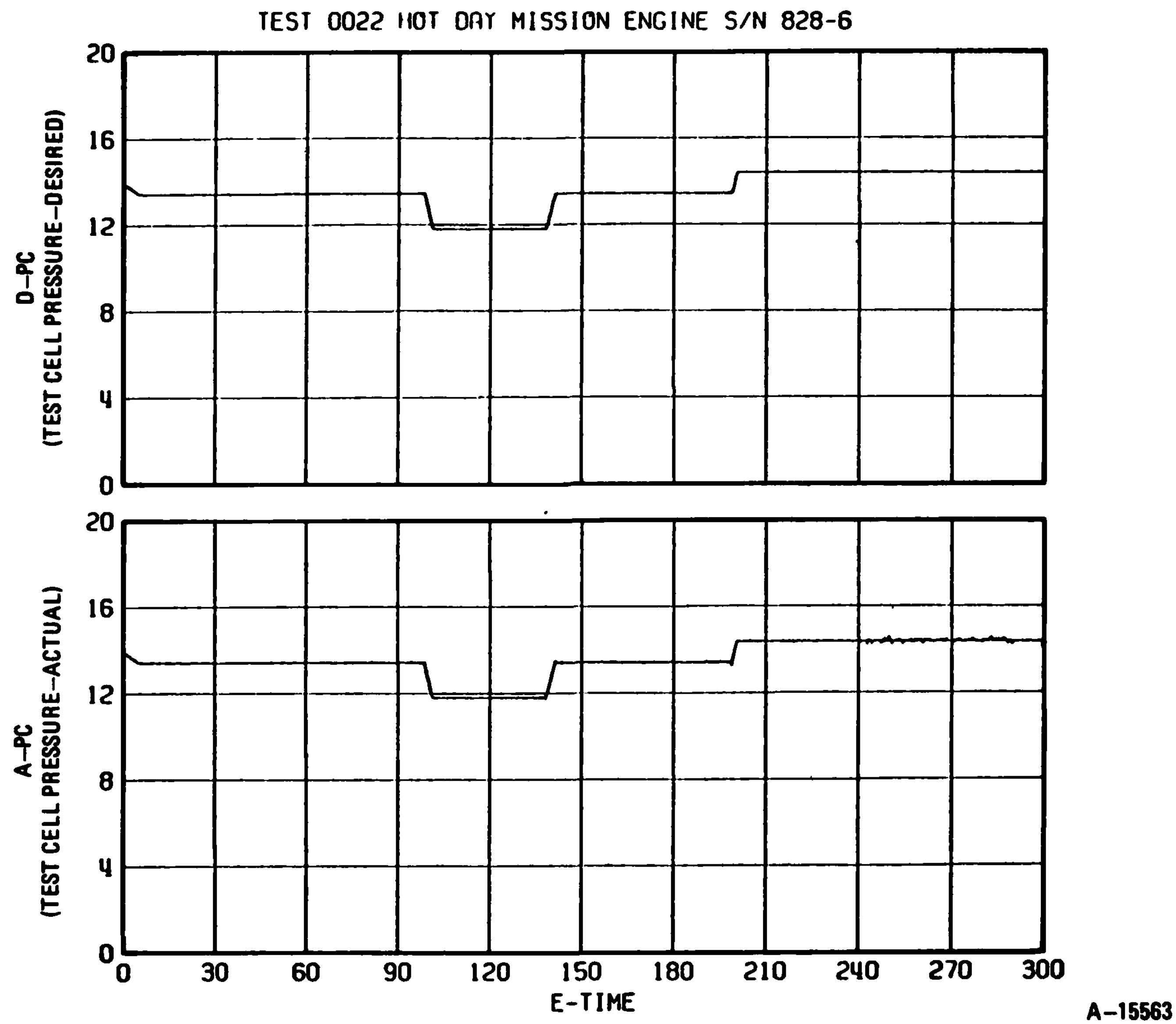


Figure 3-49. Engine 828/Build 6, Time History of Test Cell Pressure (Specification Compared to Actual Values), Hot Day Mission Simulation

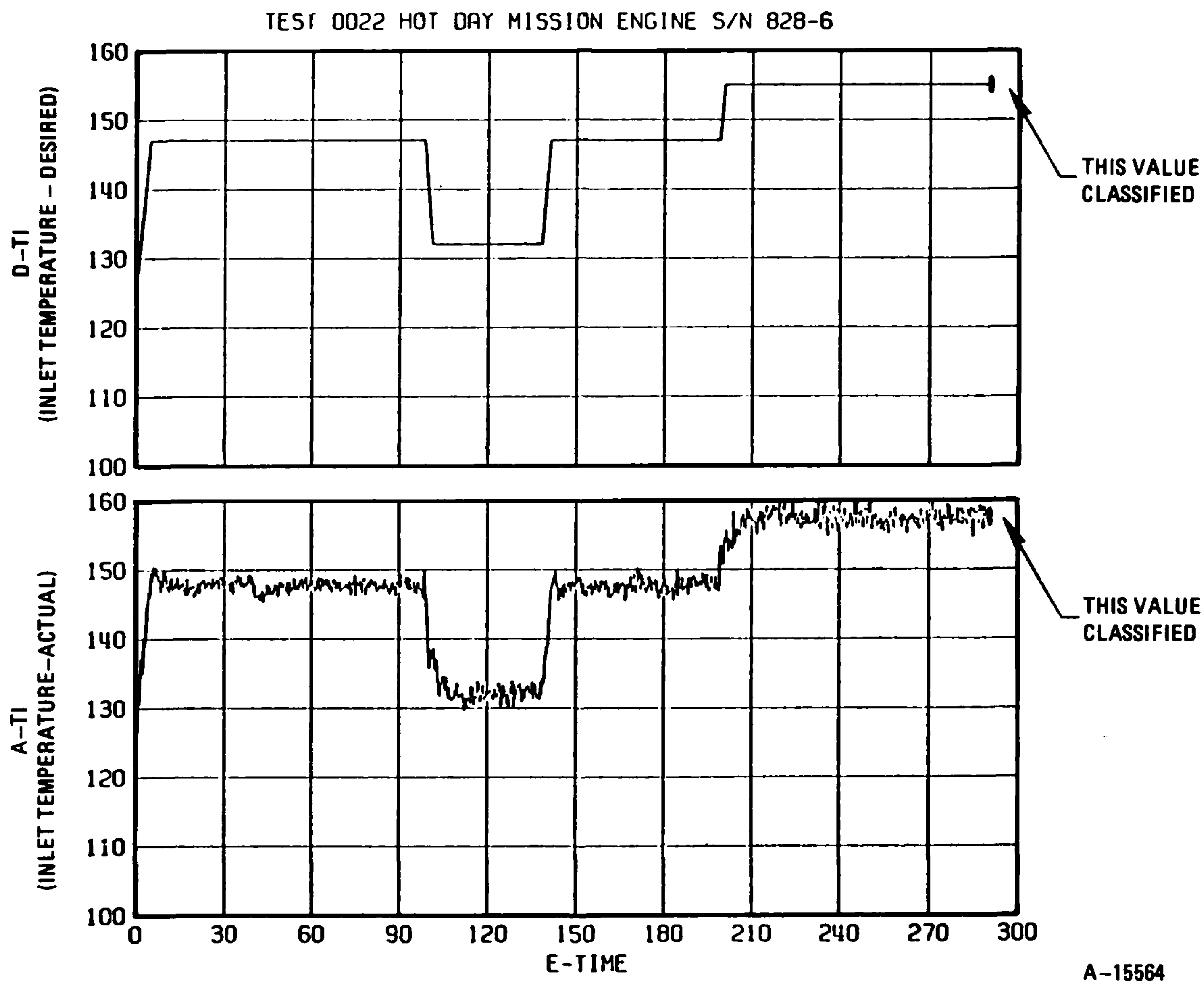


Figure 3-50. Engine 828/Build 6, Time History of Inlet Temperature (Specification Compared to Actual Values), Hot Day Mission Simulation

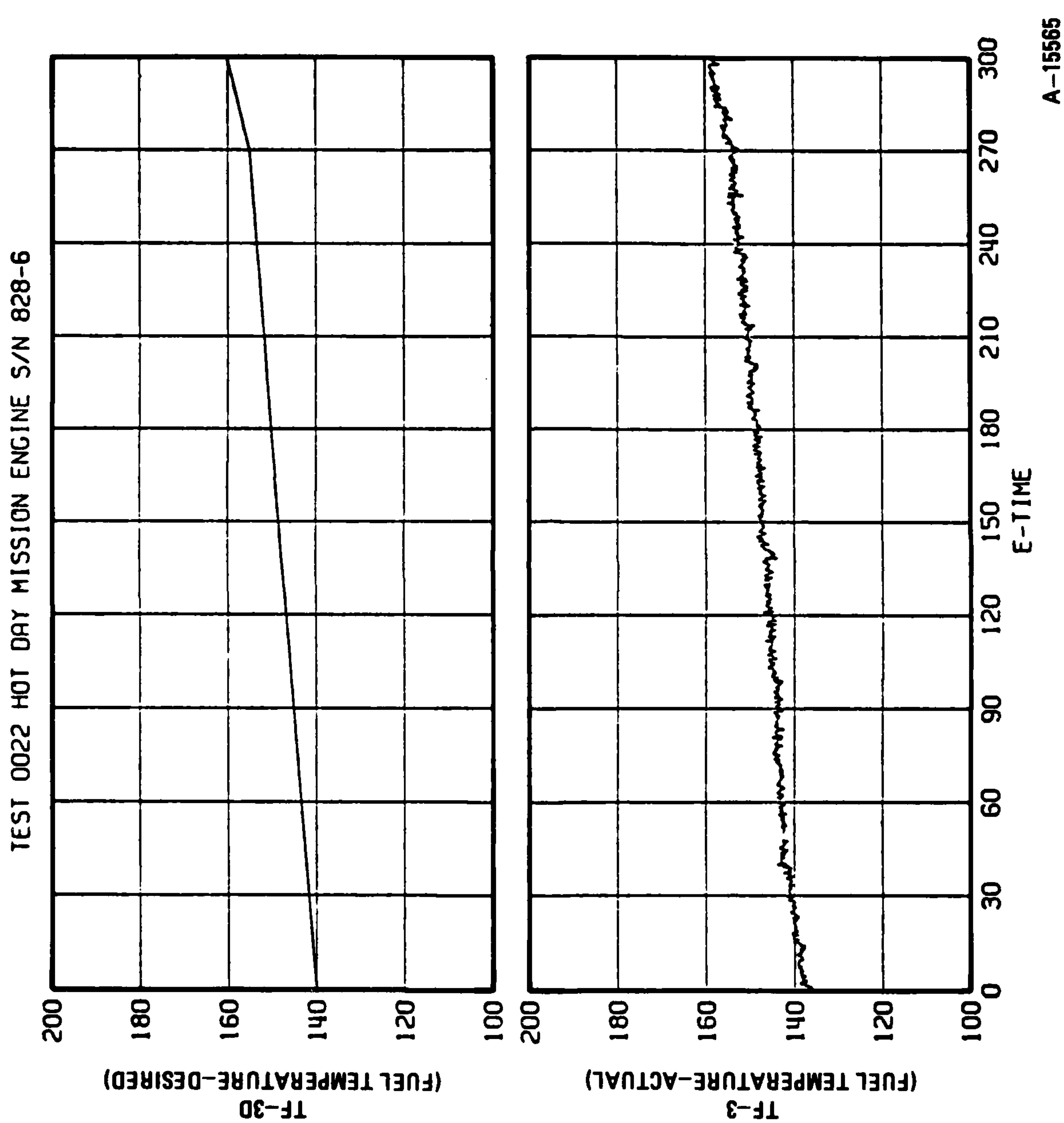


Figure 3-51. Engine 828/Build 6, Time History of Fuel Temperature (Specification Compared to Actual Values), Hot Day Mission Simulation

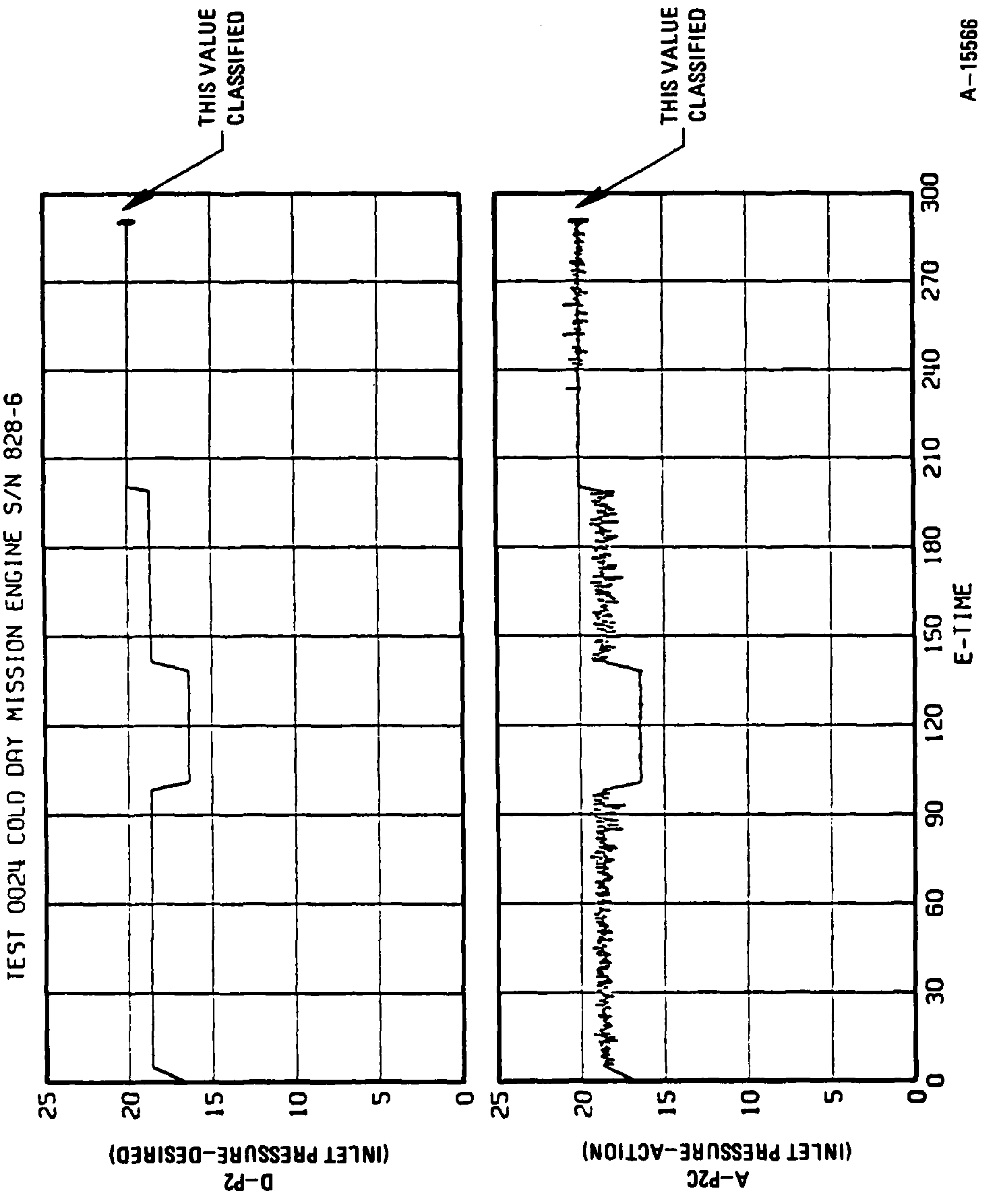


Figure 3-52. Engine 828/Build 6, Time History of Inlet Pressure (Specification Compared to Actual Values), Cold Day Mission Simulation

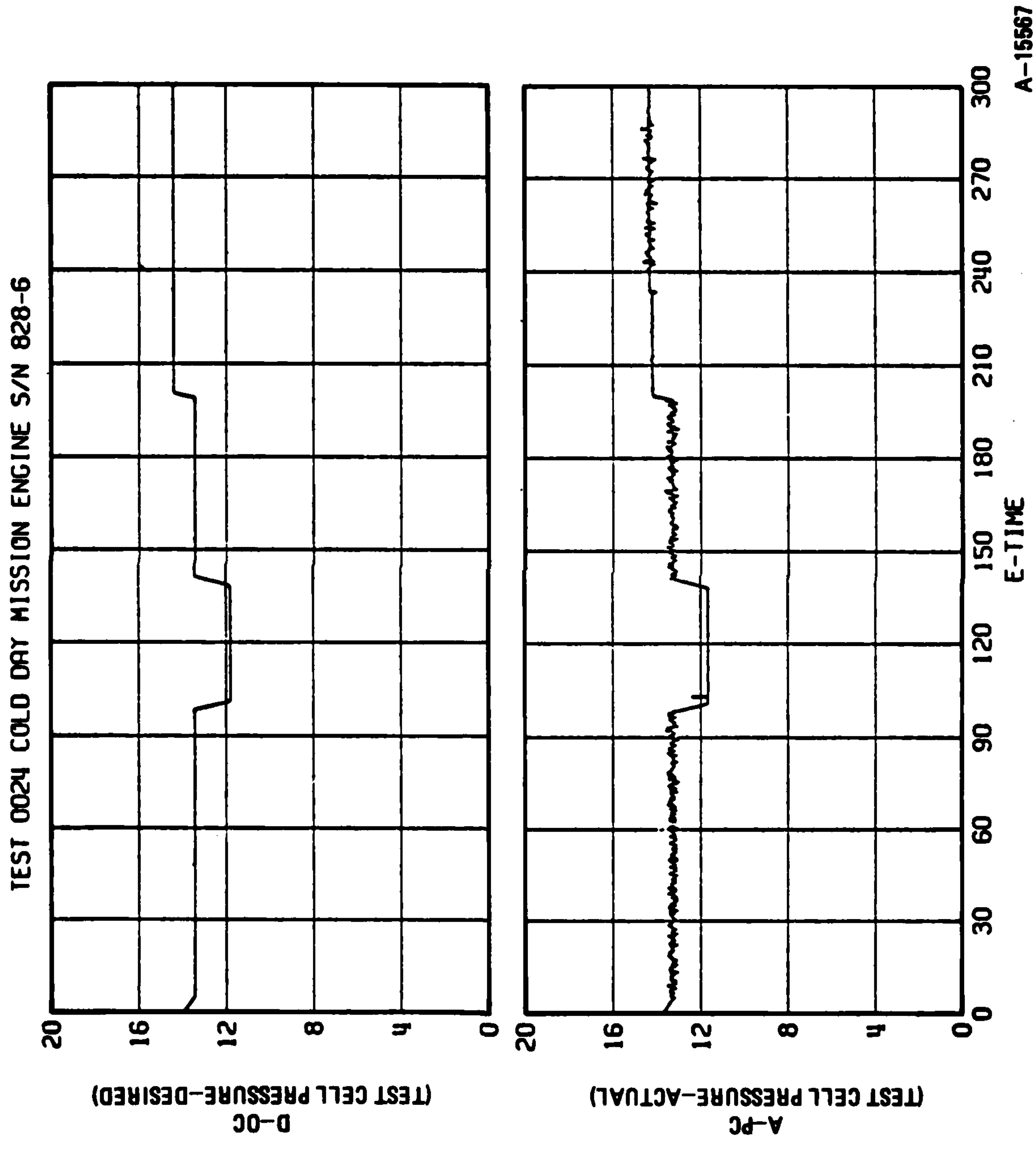


Figure 3-53. Engine 828/Build 6, Time History of Test Cell Pressure (Specification Compared to Actual Values), Cold Day Mission Simulation

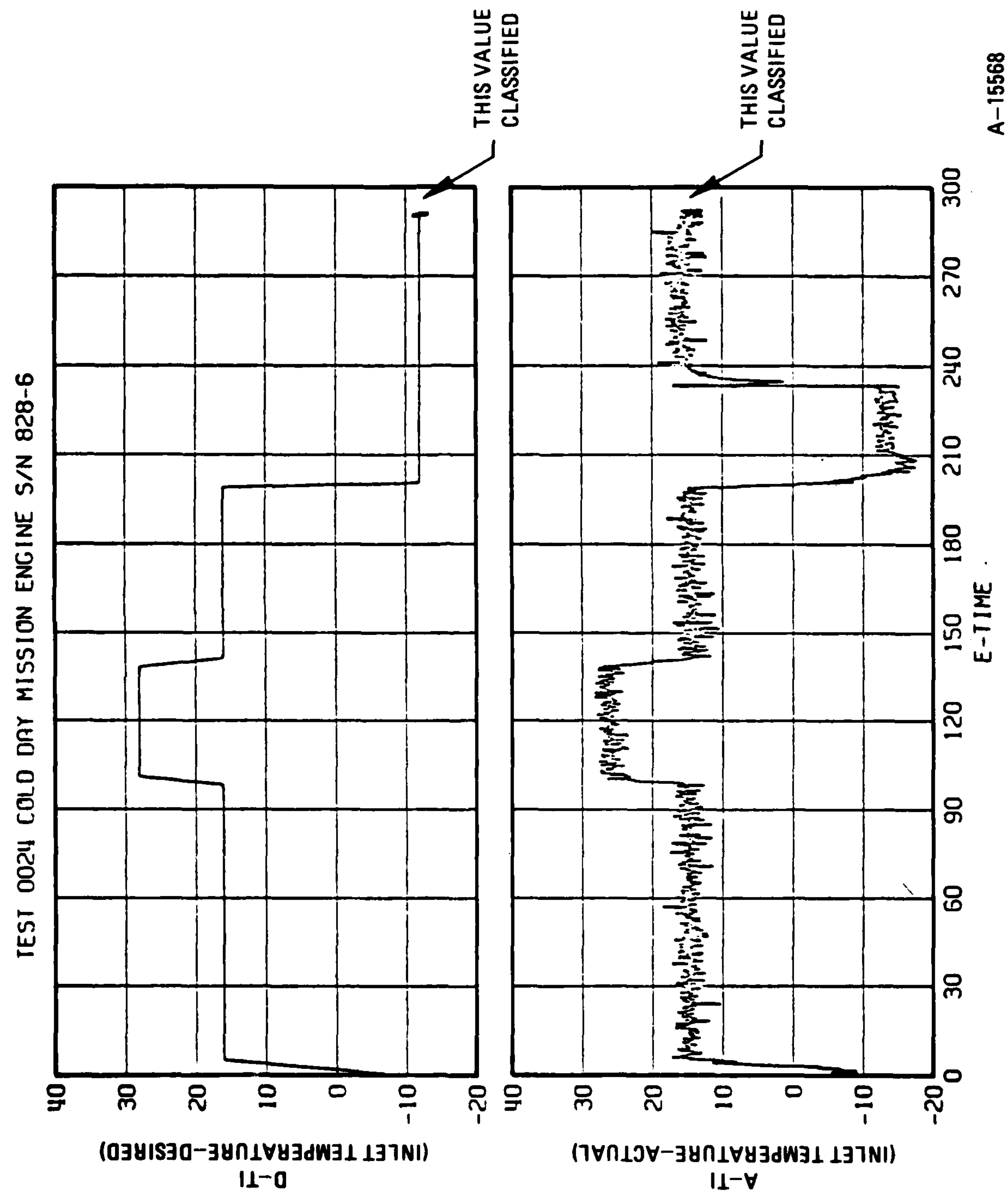


Figure 3-54. Engine 828/Build 6, Time History of Inlet Temperature (Specification Compared to Actual Values) Cold Day Mission Simulation

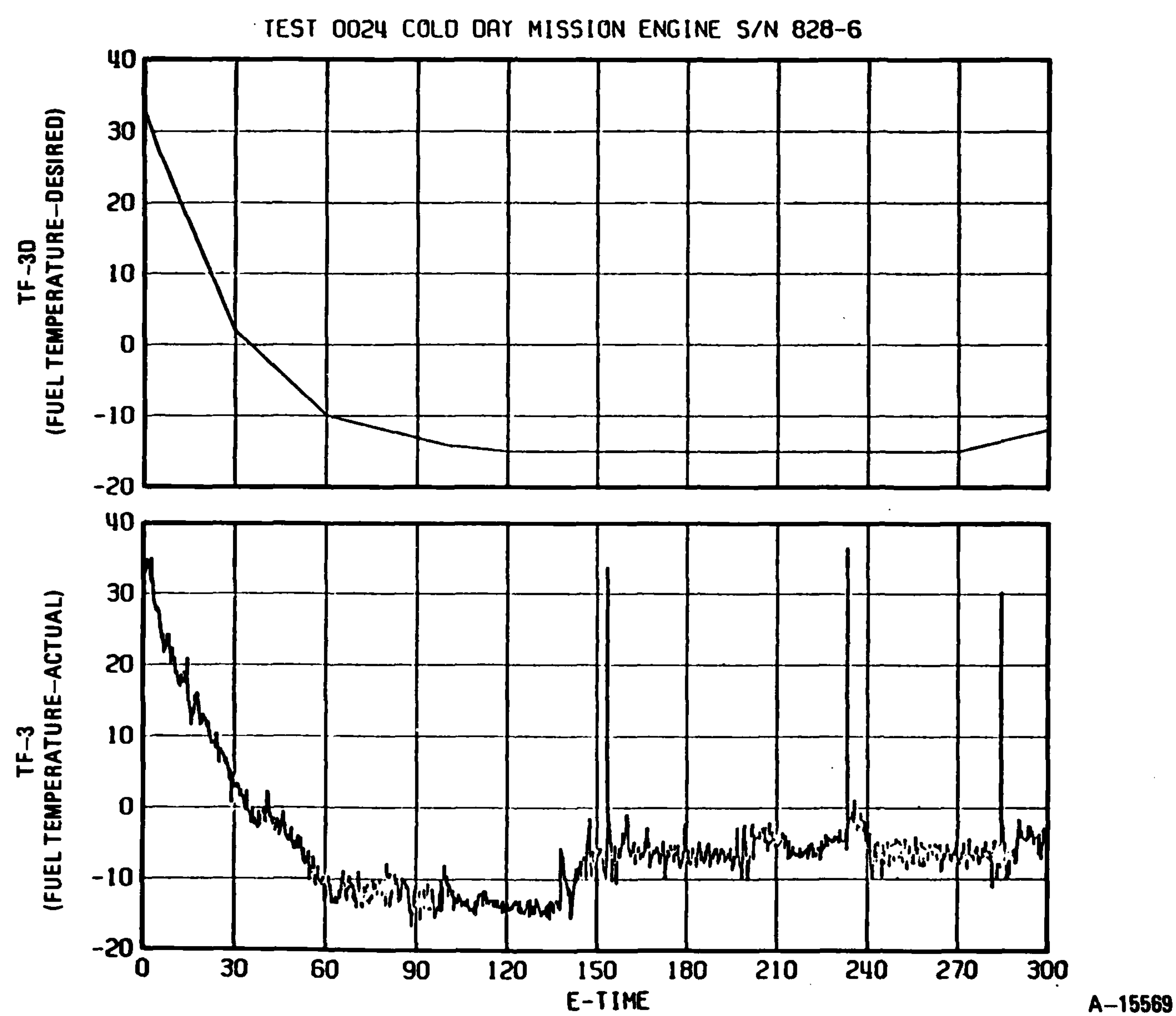


Figure 3-55. Engine 828/Build 6, Time History of Fuel Temperature (Specification Compared to Actual Values) Cold Day Mission Simulation

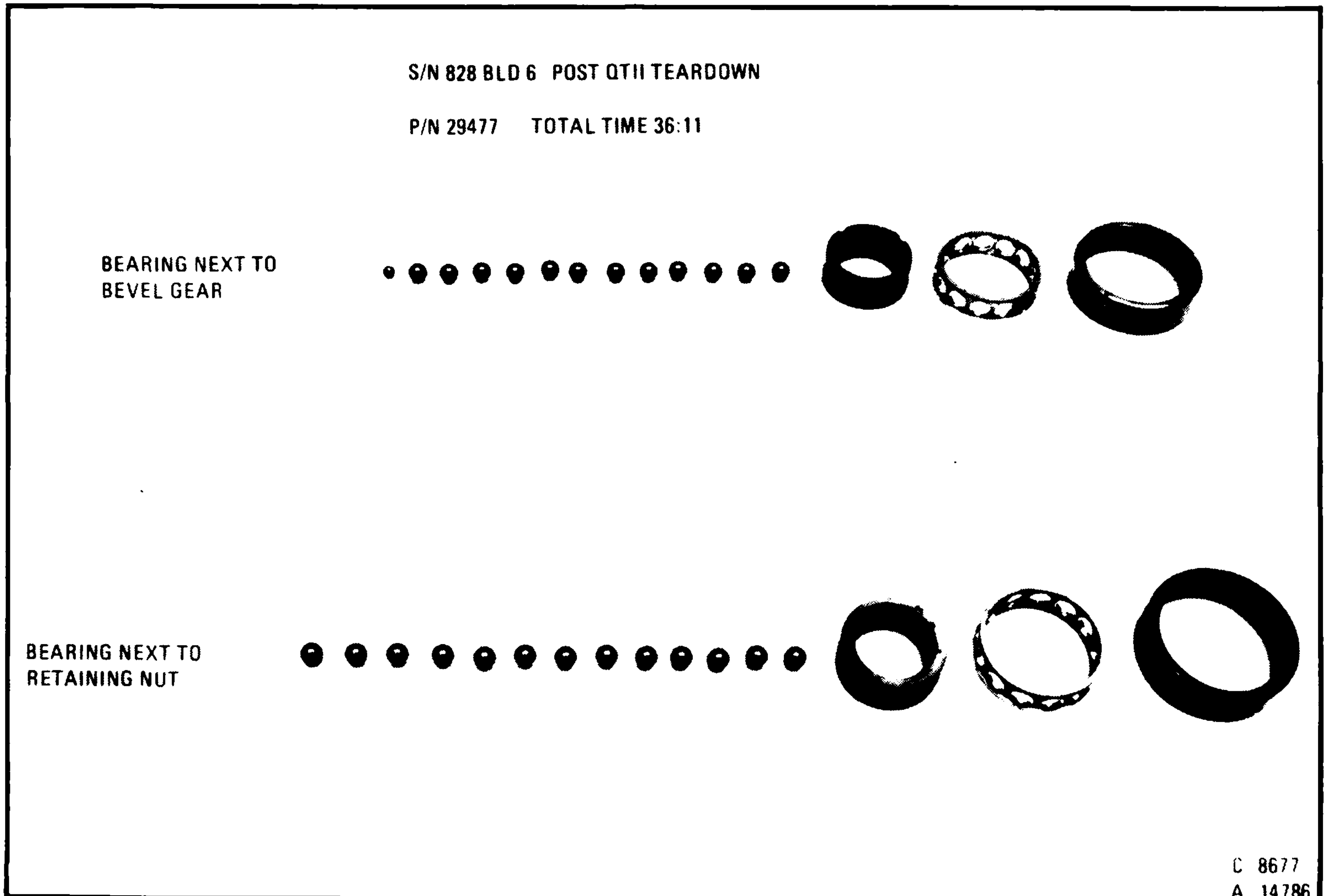


Figure 3-56. Engine 828/Build 6, Condition of Accessory Drive Bearings Observed During Post-Mission Simulation Teardown Inspection

APPENDIX A

PRE- AND POST-TEST DIMENSIONAL DATA

This Appendix is a compilation of pre- and post-test measurements on critical engine components.

ITEM TO BE INSPECTED	REF NO.	BLUEPRINT DIMENSION	PRE-TEST DIMENSION	POST-TEST DIMENSION
No. 3 Brg Seal Shroud ID	20B	1.643/1.644	1.6438	1.645
HP Compressor Aft Laby Seal Land OD	21A	1.920/1.919	1.919	1.915
HP Compressor Aft Seal Shroud ID	21B	1.920/1.921	1.9222	1.9235
Burner Front Seal Laby Land OD	22A	1.755/1.754	1.754	1.754
Burner Front Seal Shroud ID	22B	1.759/1.760	1.761	1.763
Burner Seal Behind Slinger Laby Land OD	23A	2.346/2.344	2.346	2.342
Burner Seal Behind Slinger Seal Shroud ID	23B	2.348/2.349	2.347	2.351
Burner Aft Seal 1st (Front) Land OD	24A	3.287/3.285	3.286	3.280
Burner Aft Seal 1st Land Shroud ID	24B	3.289/3.290	3.288	3.294
Burner Aft Seal 2nd Land OD	24C	3.287/3.285	3.286	3.280
Burner Aft Seal 2nd Land Shroud ID	24D	3.289/3.290	3.288	3.296
Burner Aft Seal 3rd Land OD	24E	3.287/3.285	3.286	3.281
Burner Aft Seal 3rd Land Shroud ID	24F	3.289/3.290	3.288	3.298
Burner Aft Seal 4th (Aft) Land OD	24G	3.287/3.285	3.286	3.281
Burner Aft Seal 4th Land Shroud ID	24H	3.289/3.290	3.288	3.298
No. 4 Brg Carbon Seal ID	26A	2.0010/2.0005	2.0008	2.0027
No. 4 Brg Carbon Seal Runner OD	26B	2.0010/2.0005	2.0005	2.002
No. 5 Brg Small Carbon Seal ID	27A	1.4465/1.4460	1.4463	1.4511
No. 5 Brg Small Carbon Seal Runner OD	27B	1.4465/1.4460	1.4463	1.4462
No. 5 Brg Large Carbon Seal ID	28A	2.6268/2.6262	2.6263	2.6302
No. 5 Brg Large Carbon Seal Runner OD	28B	2.6247/2.6242	2.6244	2.6240
2nd Turbine Aft Laby Seal Land OD	29A	1.866/1.863	1.864	1.860

ITEM TO BE INSPECTED	REF NO.	BLUEPRINT DIMENSION	PRE-TEST DIMENSION	POST-TEST DIMENSION
2nd Turbine Aft Laby Seal Shroud ID	29B	1.866/1.867	1.8664	1.8675
3rd Turbine Front Laby Seal Land OD	30A	1.866/1.863	1.865	1.859
3rd Turbine Front Laby Seal Shroud ID	30B	1.866/1.867	1.8664	1.8675
No. 6 Brg Front Laby Seal Land OD	31A	1.224/1.221	1.222	1.219
No. 6 Brg Front Laby Seal Shroud ID	31B	1.2245 ± 0.0005	1.2247	1.2252
Runout on 1st Fan ID Pilot with LP Nut Torqued	32A	0.001(max)	0.0005	0.001
Runout on 1st Fan Front Face for Spinner with Nut Torqued	32B	0.001 (max)	0.0008	0.0003
No. 1 Bearing End Play	33A	0.0125 (max)	N/R	0.006
No. 1 Bearing Radial Play	33B	0.0025/0.0030	0.0007	0.001
No. 1 Bearing Weight	33C	0.625 gms (max change)	71.14	70.95
Axial Clearance Between 1st Fan Platform & Stator	34	0.0236/0.0738	0.034	0.030
Bevel Gear Backlash in Gearbox Set of Bevels	39	0.003/0.013	0.006	0.011
Bevel Gear Backlash in Engine Set of Bevels	41	0.006/0.014	0.0115	N/R
No. 3 Bearing End Play	42A	0.008 ± 0.001	0.0061	0.012
Impeller Tip Dia - HP Compressor	44	6.861/6.859	6.8606	6.8620
HP Compressor Backface Clearance	45	0.020/0.042	0.031	0.029
Axial Distance - Slinger to Burner Cover Nose	46	0.066/0.105	0.109	0.076
Axial Distance - Slinger to Primary Plate OD	46A	+0.010/-0.040	-0.005	N/R
Igni[illegible] Plug Immersion Depth (Information Only)	47	Right None	0.039	0.032
		Left None	0.035	0.028

ITEM TO BE INSPECTED	REF NO.	BLUEPRINT DIMENSION	PRE-TEST DIMENSION	POST-TEST DIMENSION
Axial Distance - Back of Burner Mtg Flange to Back of Seal	48	0.596/±0.008	0.598	0.612
Burner Louver Opening (Pri Plate Outer Edge)	49A	0.037	0.035	0.032
Axial Clearance - Front of HP Turbine at Rim	50	0.1365/0.1585	0.148	0.134
No. 4 Brg Spring - Front Feet Pad Height	51C	0.023 Ref	0.0235	0.023
No. 4 Brg Spring - Rear Feet Pad Height	51D	0.023 Ref	0.0235	0.023
No. 5 Brg Spring - Front Feet Pad Height	52C	0.023 Ref	0.0235	0.023
No. 5 Brg Spring - Rear Feet Pad Height	52D	0.023 Ref	0.0235	0.0228
Bore Dia of 3rd Turbine	57	0.6875/0.6880	0.6887	0.6886
Fuel Manifold Flow Test (Flow ΔP & Pattern) at 400 pph	60B	250 ΔP	169	138
2nd Nozzle Oil Supply Tube - Flow vs ΔP	61	1.8 lbm/min (min)	1.84	1.92
Rear Hsg Oil Supply Tube - Flow Vs. ΔP	62	0.35 lbm/min (min)	0.568	0.540
Bore Dia of HP Compressor	63	1.1889/1.1892	1.210	1.217

APPENDIX B

F107-WR-400 RUN PROGRAM NO. QT21

6 NOVEMBER 1979

ADDENDUM NO. 1 TO

F107-WR-400 RUN PROGRAM QT21

15 NOVEMBER 1979

ADDENDUM NO. 2 TO

F107-WR-400 RUN PROGRAM QT21

25 MARCH 1980

ADDENDUM NO. 3 TO

F107-WR-400 RUN PROGRAM QT21

7 APRIL 1980

Williams Research Corporation

7 November 1979 CMEP 1-0773

Department of the Air Force
Aeronautical Systems Division
Wright Patterson Air Force Base
OH 45433

Attention: YZET/Charles Hutcheson

Subject: Transmittal of F107-WR-400 Run Program No. QT21 to Arnold Engineering Development Center (AEDC)

Gentlemen:

Attached are two copies of "F107-WR-400 Run Program No. QT21," dated 6 November 1979 pertaining to Mission Simulation Endurance Qualification testing to be performed on Engine No. 828 scheduled for January 1980. This run program is being provided as a guide and supplement to the Qualification Test Plan CMEP 91-4043G, Report 78-145-8, 18 October 1979, Approval Copy Version (QTP) to aid in performing the test. The QTP should be referred to for detailed information and to complete the "definition of testing" requirements. I am forwarding this run program to you for your review and transmittal of a signed copy to J. Fergus at AEDC upon your acceptance of the QTP and the attached run program.

Sincerely,

WILLIAMS RESEARCH CORPORATION

F. L. Sole
Sr. Development Engineer

R. B. Balsley
Program Manager

FS/el

cc: Letter and Attachment

R. Lewis
J. Fergus (AEDC)

Letter Only

P. Wood
R. Stephens
B. Beckett
R. Liposky
D. Merry
R. Conley

Attachment

2280 WEST MAPLE ROAD · WALLED LAKE, MICHIGAN · 48088
AREA CODE 313 624-5200 · TWX NO. 810 232-1551

F107-WR-400 RUN PROGRAM NO. QT21
6 November 1979

1.0 GENERAL INFORMATION

1.1 Increment Title

F107-WR-400 Phase II Qualification Testing

1.2 Increment Category

1.2.1 Environmental vibration test per PID specification (Reference A) paragraph 4.6.4.13.2 and WR-400 QT plan (Reference B) paragraph 3.3.3.

1.2.2 Mission simulation endurance qualification test on RJ-4 fuel per PID specification (Reference A) paragraph 4.6.3.2g and WR-400 QT plan (Reference B) paragraph 3.2.4.

1.3 Objective of Test

1.3.1 The objective of the environmental vibration test is to demonstrate that the F107-WR-400 engine is capable of successfully completing an environmental vibration test as defined in paragraph 4.6.4.13.2 and 3.3.3 in the PID specification and WR-400 QT plan respectively.

1.3.2 The objective of the mission simulation test is to demonstrate that the F107-WR-400 engine is capable of successfully completing a mission simulation endurance test with simulated terrain following as defined in paragraph 4.6.3.2g and 3.2.4 in the PID specification and WR-400 QT plan, respectively.

1.4 Test Schedule

The anticipated calendar testing period is 7 January 1980 through 31 January 1980.

1.5 Test Article Configuration

The engine to be tested will be engine No. 828 which is a Model No. XF107-WR-400 engine P/N 1029110-108 with OPEVAL and QT instrumentation.

Paragraphs 2.1 and 2.2 of the WR-400 QT plan (Reference B), the specific parts list and top assembly and basic assembly drawings submitted to the using service and test facilities should be referred to for any further information required relative to the test article definition.

F107-WR-400 Run Program No. QT21
6 November 1979
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1.6 Test Cell Configuration

The standard test cell configuration used for the F107-WR-400 FSD testing will be used. Capability for performing simulated launch starts using both air crank and pyrotechnic cartridge, and the pop start valve is required.

Williams Research Corporation (WRC) supplied engine IP bleed measuring station as shown in Figure 1 will be used. Detailed requirements concerning cell configuration and facility support requirements are provided in the WR-400 QT plan (Reference B), Section 2.6.

1.7 Security

Security is as specified in Cruise Missile Classification Guide OPNAVINST S-5513.2 of 25 January 1979.

1.8 Engine Operating Limits

The engine operating limits are defined in the table below. Two sets of values are given for each parameter. Should the engine reach the Column A value, the on-site WRC representative is to be informed immediately. No further action is to be taken unless the WRC representative deems it necessary. Should the engine then reach the Column B value, the engine is to be shut down immediately.

Parameter	A Advise WRC Representative	B Shut Engine Down
LP Rotor Speed	35,000 rpm	38,000 rpm
HP Rotor Speed	64,000 rpm	65,000 rpm
EGT Avg Steady State	Graph to be provided with engine vs Inlet Temperature	
EGT Ind Steady State		
EGT Ind During Start	QTP Fig 3-3	1700°F
#1 Brg Temp*	300°F	350°F
#2 & #3 Brg Temp	450°F	525°F
#4-5 & #6 Scav Oil Temp	450°F	525°F
Oil Pressure (Min)	40 psig	30 Steady State
Oil Pressure (Max) SS	120 psig	200 psig
Vibration Inlet**	15 g's rms	30 g's on any two channels
Vibration Triax**	15 g's rms	30 g's on any two channels
Vibration Rear Hsg**	50 g's rms	No Limit

*Bearing temperature limits in Column B are to be compared to the coldest reading when two readings are available.

**Correlation of control room monitor vibration readings and the actual engine location and direction of the accelerometer (i.e., radial, tangential or axial) being read is required.

F107-WR-400 Run Program No. QT21
6 November 1979
Page 3

1.9 Governing Documents

In the event of conflict between this document and the qualification test plan, the contents of the qualification test plan shall be considered a superseding requirement. Items 32 and 40 on the test summary sheets are an exception to this.

2.0 INSTALLATION

2.1 Installation requirements are defined in paragraph 3.2.4 of the WR-400 QT plan (Reference B).

3.0 DATA ACQUISITION

3.1 Instrumentation

The engine instrumentation requirements are as shown on the attached instrumentation requirements sheets and Table 2-IV and Appendix B of the WR-400 QT plan (Reference B).

3.2 Data Required

Data acquisition requirements are as defined in paragraph 3.2.4.6 and 2.6.3 of the WR-400 QT plan (Reference B). Steady state data during the mission simulation is to be taken for those items indicated by Table 3-I of reference B.

3.3 Data Reduction Requirements

The current T-5/F107 Data reduction program will be used to compute engine performance. The value of the turbine flow parameter is TBD. All other engine constants currently being used in the data reduction program remain unchanged except exhaust nozzle angle value and direction must be compatible with the F107-WR-400 engine nozzle. A second calculation of engine performance will be required using theta = (T2/518.67) 0.67 for fuel flow correction. Plots of data required are specified in paragraph 2.73 and Tables 2-V and 2-VI of the WR-400 QTP. A calculation of turbine inlet temperature will be required also.

4.0 TEST PROCEDURE

4.1 Test Sequence

Due to the nature of these tests, they must be run in the sequence given on the attached test summary sheet.

4.2 Oil Consumption

Oil consumption shall be determined before, during and after the mission simulation endurances. The consumption before and after the endurance shall be computed during the pre and post calibrations, items 16 and 40 respectively on the attached F107-WR-400 test summary sheets. Oil consumption during the mission simulation endurances shall be determined after items 29 and 37 on the test summary sheet. The "Drain and Weigh" method will be used to compute these consumptions. MIL-L-23699 oil will be used in the engine main oil tank.

4.3 Environmental Vibration

The environmental vibration test is to be performed as defined in paragraph 3.3.3 of the WR-400 QTP (Reference B). This test is to be completed prior to shipping the engine to AEDC.

4.4 Initial Engine Start and Checkout

Upon completion of the engine installation in the test cell, the fuel system is to be purged of air and pressurized per Appendix H of the WR-400 QT plan (Reference B).

Engine is to be operated as defined in Appendix C, paragraph 8.0, of the WR-400 QT plan (Reference B) in order to check out all instrumentation hook-ups and perform an engine trim check.

4.5 Engine Calibration Under Simulated Flight Conditions (Pre-endurance Calibration)

The pre-endurance calibration is defined in paragraph 2.7.3 of the WR-400 QTP plan (Reference B) and is to be completed as part of the testing defined by paragraph 4.4 of this run program.

4.6 Hot and Cold Day Mission Simulations

After completing paragraph 4.5 above, perform the high and low temperature mission simulation test as defined in paragraph 3.2.4 of the WR-400 QT plan (Reference B).

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6 November 1979
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4.7 Post-Endurance Calibration

The post-endurance calibrations are defined in paragraphs 3.2.4.8 and 3.2.4.10 of the WR-400 QT plan (Reference B) and are to be completed as part of the testing defined by paragraph 4.6 of this run program.

Reference: A. Prime Item Development Specification 24235WR9501A, December 1978

B. Qualification Test Plan CMEP 91-4043G Report No. 78-145-8 18 October 1979 Approval Copy Version

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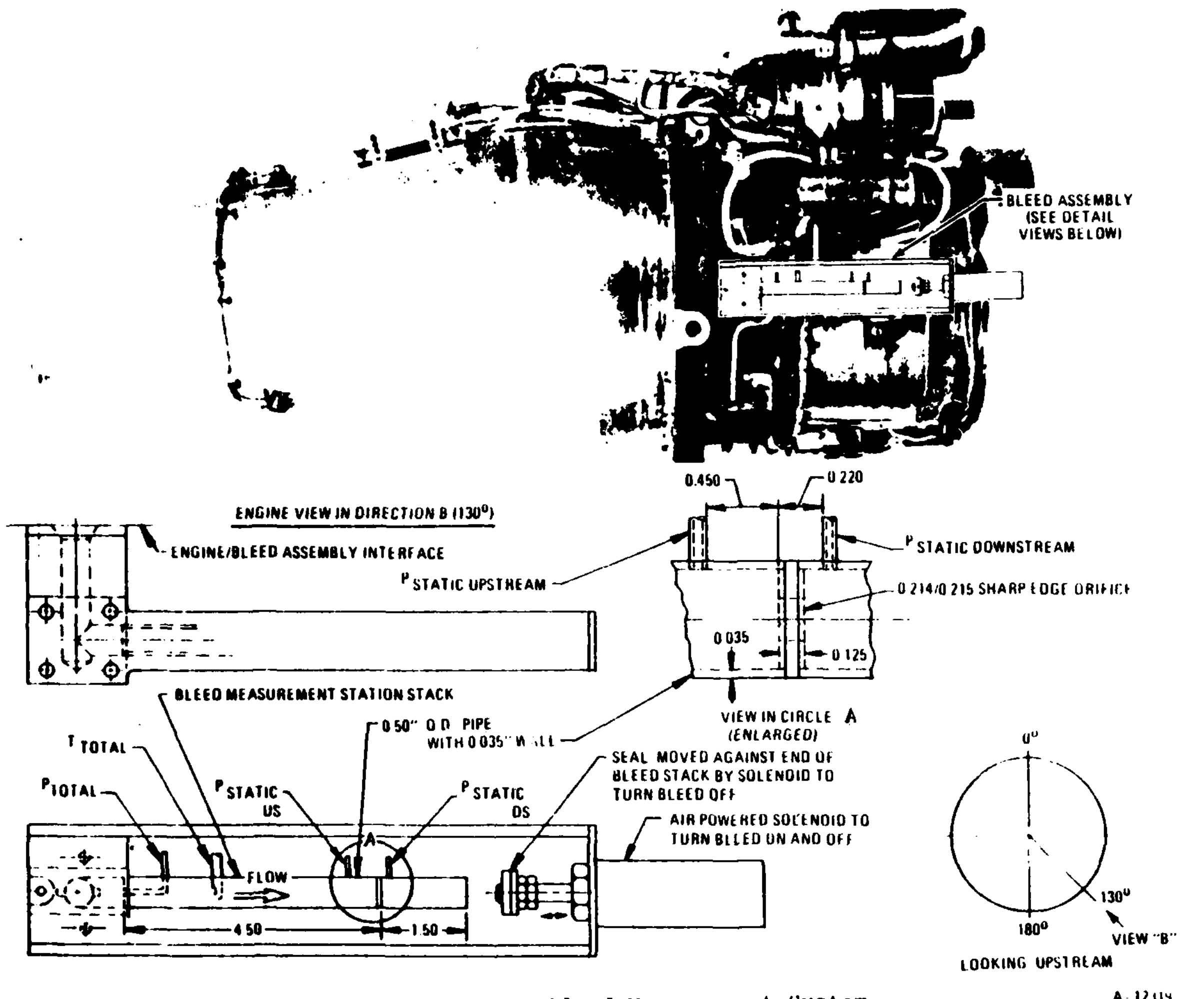


Figure 1. Engine 828 IP Bleed Measurement System.

ENGINE INSTRUMENTATION REQUIREMENTS SUMMARY

ENGINE NO. 828 — 4-6-79 — SH 1 OF 3

PARAMETER DESIGNATION	SYMBOL	TOTAL NO. OF RAKES	TOTAL NO. OF PROBES	RANGE MIN	RANGE MAX	STEADY STATE	TRANSIENT	CONTROL ROOM MONITOR	HARNESS HOOK UP	COMMENTS
TEMPERATURES (°F)										
HP Compressor Discharge Temp.	T3	3	3	-70	1000	✓				
LP Turbine Discharge Temp.	T6WI	3	3	-70	1700	✓	✓	✓	✓(Avg)	3 Flight Average
No. 1 Bearing Temp.	TB1	2	2	-70	400	✓		✓		1-Pyrometer, 1-Computer
No. 2 Bearing Temp.	TB2	2	2	-70	600	✓		✓		1-Pyrometer, 1-Computer
No. 3 Bearing Temp.	TB3	2	2	-70	600	✓		✓		1-Pyrometer, 1-Computer
No. 4-5 Scavenge Oil Temp.	TB4/5	1	1	-70	600	✓		✓		
No. 6 Scavenge Oil Temp.	TB6	1	1	-70	600	✓		✓		
No. 4-5-6 Oil Supply Temp.	TOO	1	1	-70	400	✓		✓		
Air Bleed Total Temp.	TBL	1	1	-70	300	✓				
Jet Nozzle Skin Temp.	TNOZ	4	4	-70	350	✓				Optional-Facility Supplied-Installed
Rear Hsg. Accelerometer Temp.	TV5	1	1	0	1000	✓				Optional
LP Turbine Discharge Temp.	T6	3	3	-70	1700	✓	✓	✓		Individual
Fan Discharge Temp. at Mixing Plane	T16	3	3	-70	300	✓				Individual
No. 2-3 Scavenge Oil Temp.	TB2/3	1	1	-70	600	✓		✓		
PRESSURES (PSIA)										
HP Compressor Discharge Static Press.	P3A	1	1	4	300	✓	✓	✓		Facility Transducer
Exhaust Nozzle Lip Static Press.	PNBE	4	4	0	30	✓				Optional-Facility Supplied-Installed
Tailpipe Outside Static Press.	PS7.5	4	4	0	30	✓				Optional-Facility Supplied-Installed
Oil Pressure	POPO	1	1	0	550	✓	✓	✓		Facility Transducer
Start Gas Pressure	PSC	1	1	0	850		✓			
Air Bleed Static Press. (Upstream)	PSBL-1	1	1	4	100	✓				

ENGINE INSTRUMENTATION REQUIREMENTS SUMMARY

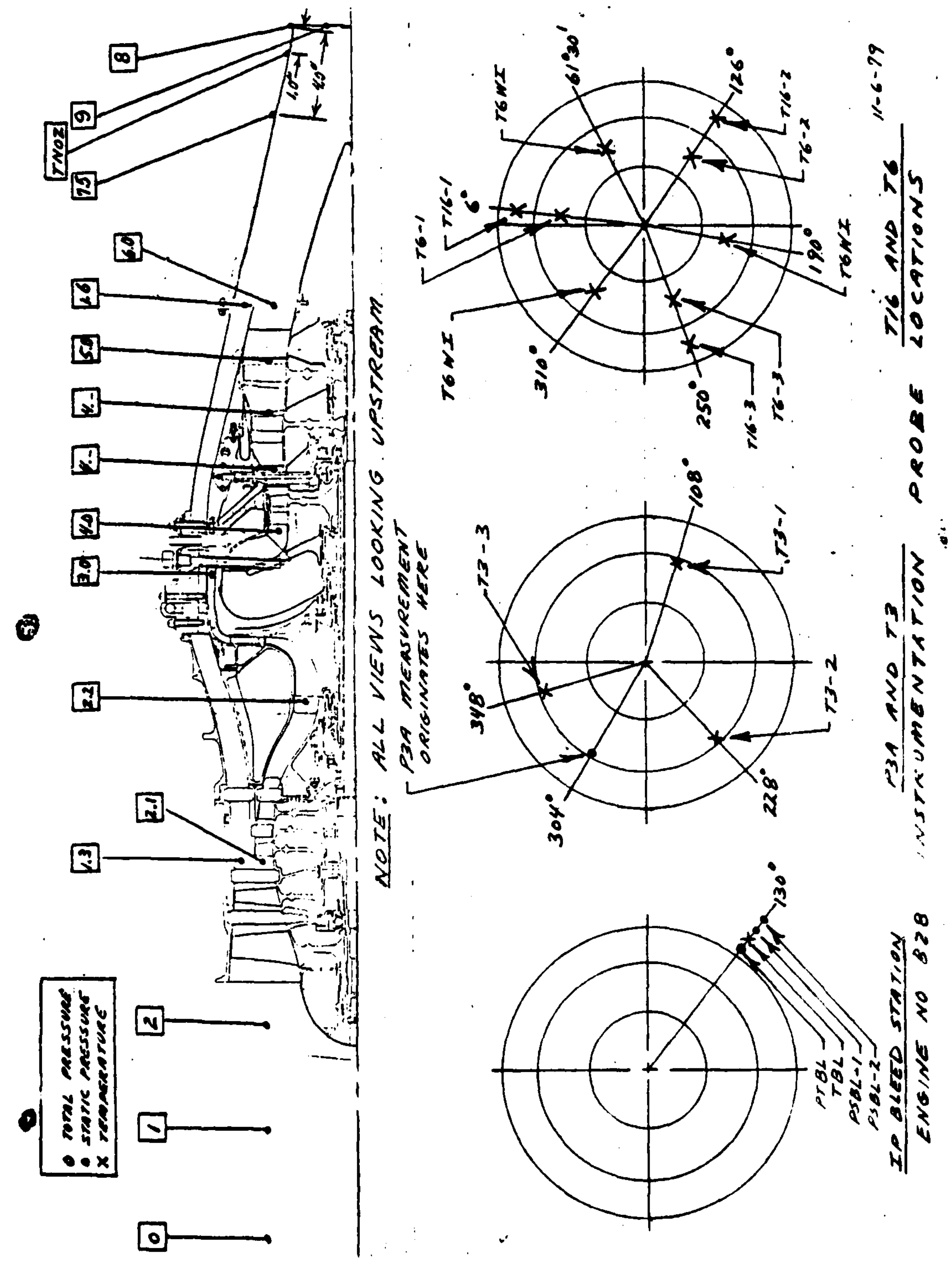
ENGINE No. 828 — 11-6-79 — SH 2 OF 3

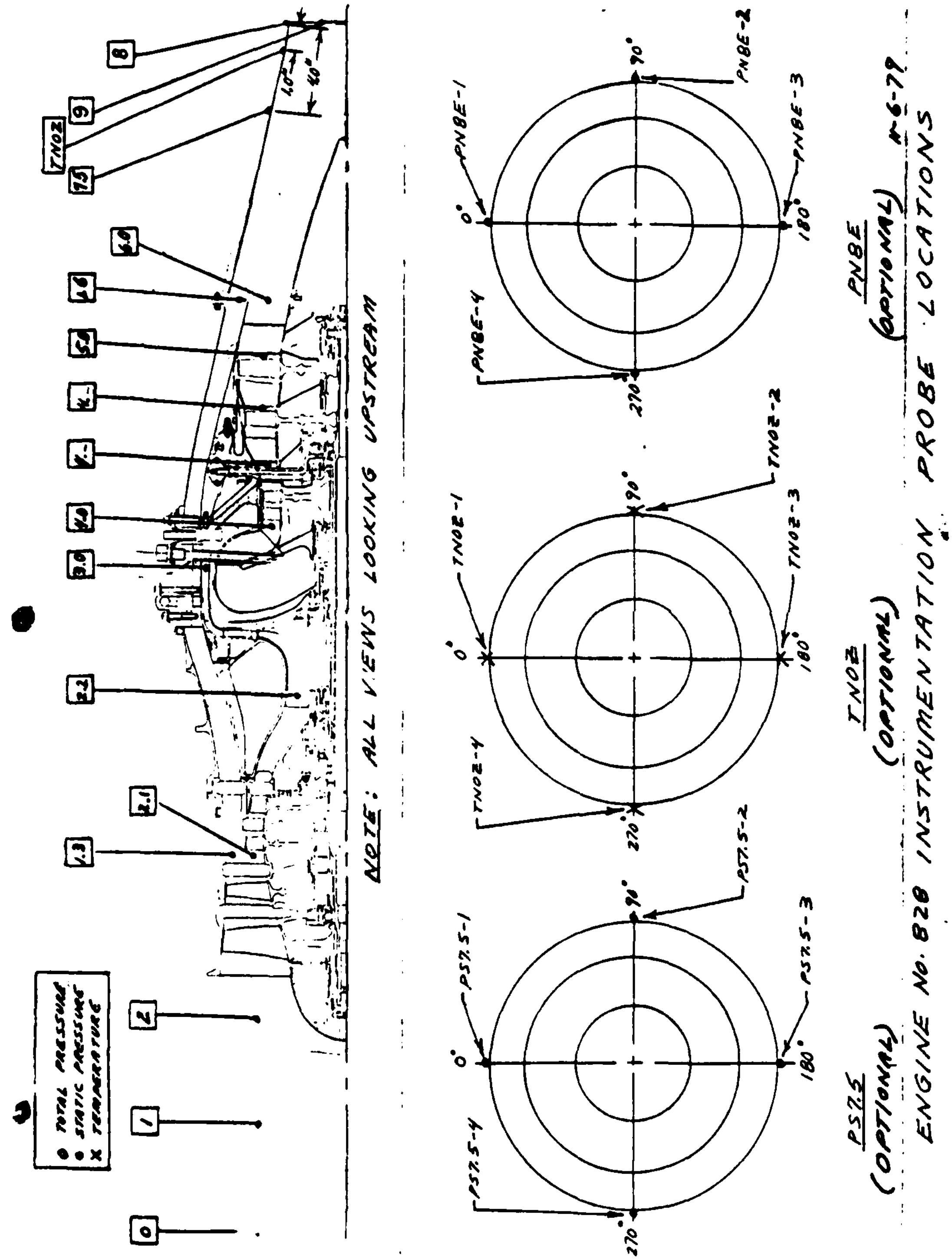
PARAMETER DESIGNATION	SYMBOL	TOTAL NO. OF RAKES	TOTAL NO. OF PROBES	RANGE MIN	RANGE MAX	STEADY STATE	TRANSIENT	CONTROL ROOM MONITOR	HARNESS HOOK UP	COMMENTS
PRESSURES (PSIA) (CONT)										
Air Bleed Static Press. (Down-stream)	PSBL-2	1	1	4	100	✓				Facility Transducer
Air Bleed Total Press.	PTBL	1	1	4	100	✓				Facility Transducer
FREQUENCIES										
LP Speed (RPM)	XN2	1	1	0	37000	✓	✓	✓		
HP Speed (RPM)	XN24	1	1	0	65000	✓	✓	✓	✓	
Fuel Flow	WF	3	3	0	600	✓	✓	✓		Facility supplied. 3 flowmeters required for performance calibrations. 1 flowmeter required for mission simulation.
VIBRATION (G'S RMS)										
Inlet Housing (Radial)	V_1	1	1	0	30	✓	✓	✓		
Interstage Hsg. Triax (Radial)	V_2	1	1	0	25	✓	✓	✓		
Interstage Hsg. Triax (Tangential)	V_3	1	1	0	25	✓	✓	✓		
Interstage Hsg. Triax (Axial)	V_4	1	1	0	25	✓	✓	✓		
Rear Housing (Radial)	V_5	1	1	0	60	✓				Optional
GENERATOR										
Generator Load 1 Volts	VOLTS 1	1	1	0	29	✓	✓			
Generator Load 2 Volts	VOLTS 2	1	1	0	40	✓	✓			
Generator Load 1 Amps	AMPS 1	1	1	0	70	✓	✓			
Generator Load 2 Amps	AMPS 2	1	1	0	70	✓	✓			
OTHER										
Power Setting (Volts D.C.)	PLA	1	1	-10.3	+3.8	✓	✓	✓		Facility
Power Setting Feedback Position	PLAFB	1	1	+0.4	+14.8	✓	✓			Volts D.C. (with source impedance of 5790 ± 5% Ohms)
Exhaust Nozzle Area	ENA	To be furnished by WRC or measured by test facility prior to test completion								

ENGINE NO. 827 — ENGINE INSTRUMENTATION REQUIREMENTS SUMMARY — 4-6-79 — SH 3 OF 3

PARAMETER DESIGNATION	SYMBOL	TOTAL NO OF RAKES	TOTAL NO OF PROBES	RANGE MIN	RANGE MAX	STEADY STATE	TRANSIENT	CONTROL ROOM MONITOR	HARNESS HOOK UP	COMMENTS
FACILITY INSTRUMENTATION* OR DERIVED PARAMETERS REQUIRED										
Engine Inlet Total Temp. (°F)	T_1	1	8	-70	+165	✓	✓	✓		Facility
Fuel Supply Temp. at Engine (°F)	TF	3	3	-70	+200	✓	✓	✓		
Engine Inlet Total Press. (PSIA)	PIB	4	4	4	30	✓	✓	✓		
Cell Static Press. (PSIA)	PSO	4	4	0	30	✓	✓			
Fuel Press. at Control Inlet (PSIA)	PF3	1	1	0	50	✓	✓	✓		
Time of Day						✓				
Gross Thrust (Lb)	FG	1	2	0	1000	✓				Facility Calculated
Net Thrust (Lb)	FN	1	2	-300	+800	✓				
Airflow (Lb/sec)	WA			0	20	✓				
Airbleed Airflow (Lb/sec)				0	0.3	✓				Calculated from engine instrumentation
Start Number (Each Build, Each Engine)							✓			
Time to Stable Speed on Starts							✓			
Time to Oil Pressure Indication							✓			
Time to Stable Oil Pressure Indication							✓			
Cartridge Initiation Voltage				0	28		✓			(Volts D.C.)
Oil Consumption						✓				Check per Run Program
Total Endurance Time										Facility

* Additional facility requirements are also indicated on preceding sheets.


TOTAL PRESSURE
STATIC PRESSURE
TEMPERATURE
0
1
2
1.3
2.1
2.2
3.0
4.0
5.0
6.0
7.5
9
8
TNOZ
NOTE: ALL VIEWS LOOKING UPSTREAM
P3A MEASUREMENT ORIGINATES HERE
PTBL
TBL
PSBL-1
PSBL-2
130°
IP BLEED STATION
ENGINE NO 828
T3-1
T3-2
T3-3
108°
348°
304°
228°
P3A AND T3
INSTRUMENTATION
T6-1
T16-1
T6-2
T16-2
T6-3
T16-3
T6WI
6°
61°30'
126°
190°
250°
310°
T16 AND T6
LOCATIONS
PROBE
11-6-79


NOTE: ALL VIEWS LOOKING UPSTREAM
TOTAL PRESSURE
STATIC PRESSURE
X TEMPERATURE
PS7.5 (OPTIONAL)
TNOZ (OPTIONAL)
PNBE (OPTIONAL)
ENGINE No. 828 INSTRUMENTATION PROBE LOCATIONS

FWP-WR-400 QUALIFICATION TEST SUMMARY SHEET* TEST NO. QT21 ENGINE S/N 828 SHEET NO 1 of 2 11-7-79

ITEM NO	QTP PARAGRAPH	TEST SITE	TEST DESCRIPTION	ALTITUDE	MACH NO.	BROW AMB TEMP (°F)	RAM INLET TEMP (°F)	EXHAUST STATIC PRESS	RAM INLET PRESS	FUEL TEMP (°F)	AIR & SURROUNDING ENGINE (°F)	PRE-TEST FUEL TEMP (°F)	PRE-TEST SOAK TIME (HRS)	SHAFT POWER EXTRACTION	AIR BLEED	PLA VOLTS	RUN TIME MINUTES	DISTORTION SCREEN NO.		DATE TEST COMPLETED
1	C4.1	WRC	INITIAL RUN	SL						AMB	AMB			0.0	0.0			NO		
2	C4.1.1	WRC	INSPECTION AFTER INITIAL																	
3	C4.1.2	WRC	PENALTY RUN (IF REQ'D)	SL						AMB	AMB			0.0	0.0			NO		
4	C4.1.3	WRC	INSPECTION AFTER PENALTY RUN (IF REQ'D)																	
5	2.7.6 2	WRC	CONTROL & TEMP SENSING SYSTEM CALIBRATION																	
6	C4.2	WRC	TRIM	SL						AMB	AMB			5.0	MAX			NO		
7	C4.3	WRC	FINAL RUN	SL						AMB	AMB			0.0/5.0	0.0/MAX	A/R		NO		
8	C4.4	WRC	REJECT/RETEST (IF REQ'D)	SL						AMB	AMB			A/R	A/R	A/R		NO		
9	C4.3	WRC	COMPLETE TIME REQUIREMENT TO 4:00, 13 STARTS (IF REQ'D)	SL						AMB	AMB			0.0	0.0	0.0/-2.15	A/R	NO		
10	C4.5	WRC	PREPARE FUEL SYSTEM FOR SHIPMENT																	
11	C7.0	WRC	PREPARE TO SHIP (WEIGHING, PACKING, ETC)																	
12	3.3.3	BENDIX	ENVIRONMENTAL VIBRATION TEST																	
13	C8.0	AEDC	FUEL SYSTEM PURGE																	
14			INSTRUMENTATION CHECK	SL/5K	0/.90		40/80			AMB	AMB			0.0/5.0	0.0/MAX	-2.15/.56K	:03/:05	NO		
15			TRIM CHECK	SL	0	59	59	29.92	29.92					5.0	MAX	-0.3 +4.8 +3.65				
16	2.7.3		ENGINE CALIBRATION		.70		110		41.50							SEE NOTE				
17	C8.0		ADJUST TRIM (IF REQ'D)													A/R				
18			RECALIBRATION (IF REQ'D)													+3.65 +4.8 -0.3				
19	2.7.3		COMPLETE TIME REQUIREMENT TO 4:55 (IF REQ'D)		.65		103		38.74					0.0	0.0	0.0	A/R			
20			DRAIN & WEIGH OIL; COMPUTE OIL CONSUMPTION																	
21			REPLACE OIL, FILTER, IGNITERS; INSPECT FOR LEAKS.																	
22	2.7.4		COMPRESSED AIR START	SL/5K	0/.70		40/80			AMB	AMB			0.0	0.0	-7.15		NO		
23			CHECK RUN/TRIM RECHECK (IF ENGINE RETRIMMED)	SL	0	59	59	29.92	29.92					5.0	MAX	-0.3 +1.6 +3.65				
24			CHECK RUN IF ENGINE NOT RETRIMMED	SL/5K	0/.70		40/80							0.0/5.0	0.0/MAX	SLK/-2.15	:05/:01			
25			INSPECT FOR LEAKS, REPEAT CHECK RUN AS REQUIRED. SERVICE OIL SYSTEM.																	
26			INSTALL CARTRIDGE																	
27	3.2.4.7		CARTRIDGE START	1.5K	.50	97.	125	28.34	33.62	140	AMB			6.2	0.159	+3.65		SDI		

F107-WR-400 QUALIFICATION TEST SUMMARY SHEET* TEST NO. QT21 ENGINE S/N 828 SHEET NO. 2 OF 2 11-7-79

ITEM NO.	QTP PARAGRAPH	TEST SITE	TEST DESCRIPTION	ALTITUDE	MACH NO.	EQUIV AMB TEMP (°F)	RAM INLET TEMP (°F)	EXHAUST STATIC PRESS	RAM INLET PRESS	FUEL TEMP (°F)	AIR T. SURROUNDING ENGINE (°F)	PRE-TEST SOAK TEMP (°F)	PRE-TEST SOAK TIME (HRS)	SHAFT POWER EXTRACTION	AIR BLEED	PLA VOLTS	RUN TIME MINUTES	DISTORTION SCREEN NO.		DATE TEST COMPLETED
28	3.2.4.7	AEDC	HOT DAY CYCLE	FIG 3-6	.70	FIG 3-6		FIG 3-6		FIG 3-7	SEE NOTE 2			6.2	0.6%	TABLE 3-I		GDI		
29			COOL DOWN	.6K	.60	A/R	60	28.28	32.35	AMB	AMB			0.0	0.0	-7.15	:02			
30	3.2.4.4 3.2.4.8		COMPUTE OIL CONSUMPTION																	
31	3.2.4.8		REPLACE OIL, FILTER, IGNITERS & #1 BEARING																	
32			RECERTIFICATION	SL	.70	59	110	29.92	41.50	AMB	AMB			5.0	MAX	+1.0 +2.2 +3.65		NO		
33			INSPECT FOR LEAKS, REPEAT CHECK RUN (ITEM 30) IF REQD. SERVICE OIL SYSTEM																	
34	2.7.4		INSTALL CARTRIDGE																	
35	3.2.4.9		CARTRIDGE START	1.5K	.50	-30	-9	28.34	33.62	+32	AMB			6.2	0.15%	+3.65		GDI		
36			COLD DAY CYCLE	FIG 3-6	.70	FIG 3-6		FIG 3-6		FIG 3-7	SEE NOTE 2					TABLE 3-I				
37			COOL DOWN	.6K	.60	A/R	60	29.28	32.35	AMB	AMB			0.0	0.0	-7.15	:02			
38	3.2.4.10 3.4.9.1		COMPUTE OIL CONSUMPTION																	
39			REPLACE OIL. REPLACE IGNITERS & OIL FILTER (IF REQD) (SEE NOTE 3)																	
40			RECALIBRATION	SL	.70	59	110	29.92	41.50	AMB	AMB			5.0	MAX	+1.0 +2.2 +3.65		NO		
41			COMPUTE OIL CONSUMPTION																	

*THESE SHEETS ARE PROVIDED AS AN AID IN PERFORMING THE TEST. PLEASE REFER TO RUN PROGRAM QT21 AND THE QTP FOR DETAILED INFORMATION AND INSTRUCTIONS FOR PERFORMING THE TEST.

NOTE 1: PLA VALUES ARE -7.15, +1.6, -0.27, +1.0, +2.2, +3.65 VDC.

NOTE 2: THE AIR WHICH PASSES OVER THE ENGINE WILL BE TAKEN FROM THE FACILITY INLET AIR SUPPLY TO THE TEST CELL AND WILL BE AS CLOSE TO THE INLET TEMPERATURES AS PRACTICAL.

NOTE 3: WRC REPRESENTATIVE WILL DECIDE IF OIL FILTER REPLACEMENT IS REQUIRED BY EXAMINATION OF THE OIL DRAINED FROM THE ENGINE.

1 November 1979

ATTACHMENT No. 1
Engine S/N 828 Oil Consumption Measurement

The following procedure is intended to give a good measurement of oil consumption during the portions of testing on engine S/N 828 indicated in the following table:

Required	Summary Sheet Item No.	Test Description	Oil System: Engine only	Oil System: Engine and Aux Tank	Oil Type: Eng	Oil Type: Aux
X	16	Pretest Calib	X		*	
X	27-29	Mission Sim Hot Recertification	X		*	
X	35-37	Mission Sim Cold Endurance	X		*	
X	40	Recalibration Base Line Check	X		*	

*Oil type is MIL-L-23699

The table specifies when checks are required and whether check is only using engine oil system or both engine and the auxiliary oil system. Oil types that will be used in the main tank and the auxiliary oil tank are indicated in the above table. For each consumption run, it will be necessary to document the specific gravity of the oil in the engine before and after the run in order to accurately compute consumption in gallons per hour. These specific gravity checks should be made after the oil has cooled to approximately 75°F. All oil drained from the system is to be retained and returned to WRC with the engine. Each container is to be tagged as to which part of the engine it was drained from, date drained, and time drained.

Detailed procedures for computing consumption using engine oil system only and engine and auxiliary oil systems together are provided below. In calculating the oil consumption for the test using the methods defined below, care must be taken to determine the exact amount of oil put in the engine and drained from the engine. For example, if the oil is put in a beaker or graduate for easier pouring into the engine, that beaker or graduate should be weighed clean, with the oil in it and after the oil has been poured into the engine. It takes very little oil clinging to the container to alter the measurement. Some rough checks indicate that 2-3 grams cling to the container every time it is used, and this can represent 10 to 15 percent of the oil usage during a 20 minute run.

1 November 1979
Attachment No. 1
Page 5

1.8.12 Determine the volume of oil in the engine at the beginning of the test from the weight in 1.5.5 and the specific gravity from 1.5.5. Record ____________ gallons.

1.8.13 Determine the volume of oil in the engine oil tank at the end of the test from 1.8.4 and 1.8.5. Record ____________ gallons.

1.8.14 Determine the volume of oil in the 2-3 cavity at the end of the test from 1.8.6 and the specific gravity from either 1.8.6 or 1.8.5. Record ____________ gallons.

1.8.15 Determine the volume of oil consumed during test. (1.8.10) + (1.8.12) - (1.8.13) - (1.8.14). Record results. ____________ gallons.

1.8.16 Determine the oil consumption rate in gal/hr from the engine run time (record ____________) and the oil consumed (1.8.15). Record result. ____________ gal/hr.

1.9 NOTE: Before operating engine again, be sure engine has been serviced with oil.

2.0 OIL CONSUMPTION MEASUREMENT - Engine System Only

2.1 The procedure for performing an oil consumption check using the engine oil system only is defined below. Steps 2.1.1 through 2.1.5 must be completed within 30 minutes of shutdown following an engine run equivalent as a minimum to the warm up run defined in attachment no. 2.

2.1.1 Drain the engine oil tank and the 2-3 cavity for eight minutes if not already drained. Replace the oil tank and gearbox drain plugs.

2.1.2 Weigh the empty container that will be used to add oil to the engine. Record weight ____________.

2.1.3 Add 825 ml of the oil specified by the table above to the container and weigh the container with the oil in it. Record weight ____________.

2.1.4 Pour the oil from the container into the engine oil tank. Then weigh the container and record weight ____________.

2.1.5 Determine the amount of oil added to the engine by subtracting 2.1.4 from 2.1.3. Record ____________. Measure specific gravity of oil from the batch of oil used. Record ____________.

2.2 Perform the engine run during which oil consumption is to be measured.

2.3 The following steps are necessary to determine oil consumption after completing 2.2 above.

2.3.1 Weigh the container that the oil will be drained into and record the weight ____________.

2.3.2 At 10 minutes after shutting the engine down, begin draining the oil from the engine. Drain both the oil tank and the 2-3 cavity into the container. Drain for eight minutes. Weigh the oil and the container. Record weight____________.

2.3.3 Subtract the weight of the container 2.3.1 from the weight of the oil and container 2.3.2 to obtain the weight of the oil drained. Record weight _______________.

2.3.4 Subtract the weight of the oil drained from that of the oil added in 2.1.5 to determine the weight of oil consumed. Record ______________.

2.3.5 From the weight of oil consumed 2.3.4, the specific gravity of the oil 2.1.5, and the engine run time, calculate the oil consumption rate in gal/hr. Record ____________.

2.3.6 Install the drain plugs in the oil tank drain and the 2-3 cavity drain.

2.4 NOTE: Before operating engine again, be sure engine has been serviced with oil.

jb/hr9

ATTACHMENT NO. 2

ENGINE WARM UP RUN

5 September 1979
Page 1 of 1

1. Service engine oil system, if required, per direction of WRC.
2. Air start to idle.
3. Run 2 minutes at idle while checking engine health parameters.
4. Accel to 60K N_2 - run 6 minutes minimum.
5. Decel to idle - run 2 minutes cooldown.
6. Shut down.
7. Drain engine oil - minimum drain time is 8 minutes to assure thorough draining.

jb/hr9

Williams Research Corporation

16 November 1979 CMEP 1-0786

Department of the Air Force
Aeronautical Systems Division
Wright-Patterson Air Force Base
OH 45433

Attention: YZET/Charles Hutcheson

Subject: Transmittal of F107-WR-400 Addendum No. 1 to F107-WR-400 Run Program No. QT21 to Naval Air Propulsion Center (NAPC)

Gentlemen:

Attached are two copies of "Addendum No. 1 to F107-WR-400 Run Program No. QT21," dated 15 November 1979. This addendum pertains to addition of oil tank pressure instrumentation to and revisions to engine operating limits for engine No. 328. I am forwarding this addendum to you for your review and transmittal of a copy to R. Burns at NAPC upon your acceptance of it.

Sincerely,

WILLIAMS RESEARCH CORPORATION

F. L. Sole
Sr. Development Engineer

R. B. Balsley
Program Manager

mr/mrl

cc: Letter and Attachment:

R. Lewis
R. Burns (NAPC)

Letter Only:

P. Wood
D. Best
R. Stephens
D. Merry
B. Beckett
R. Conley

Attachment(s)

2280 WEST MAPLE ROAD · WALLED LAKE, MICHIGAN · 48088
AREA CODE 313 624-5200 · TWX NO 810 232 1551

ADDENDUM NO. 1 TO
F107-WR-400 RUN PROGRAM NO. QT21
15 November 1979

Reference: F107-WR-400 Run Program No. QT21, dated 6 November 1979

The purpose of this addendum is to provide further definition to the testing required on Engine No. 828. The testing is to be performed as defined in the above reference with the following exceptions:

1. The following instrumentation is added to the instrumentation requirements and is to be read by a facility transducer.

Parameter Designation	Symbol	Total No. of Rakes	Total No. of Probes	Range Min	Range Max	Steady State	Transient	Control Room Monitor
Pressures (PSIA)								
Oil Tank Pressure	PTANK	1	1	0	40	✓	✓	✓

2. In paragraph 1.8, Engine Operating Limits of reference A, the following engine operating limits are revised to the values indicated below or added as indicated below. If not listed below, the limit remains as cited in reference A.

Parameter	A Advise WRC Representative	B Shut Engine Down
Revised:		
#1 Brg Temp*	300°F	350°F
#2 & #3 Brg Temp	450°F	525°F
#4-5 & #6 Scav Oil Temp	450°F	525°F
Oil Pressure (Min)	40 psig	30 psig Steady State
Oil Pressure (Max) SS	120 psig	200 psig
Vibration Inlet	15 g's rms	30 g's on any two channels
Vibration Triax	15 g's rms	30 g's on any two channels
Added:		
Oil Tank Pressure	Graph to be provided with engine Versus corrected LP rotor speed	

Addendum No. 1 to F107-WR-400 Run Program No. QT21
Page 2

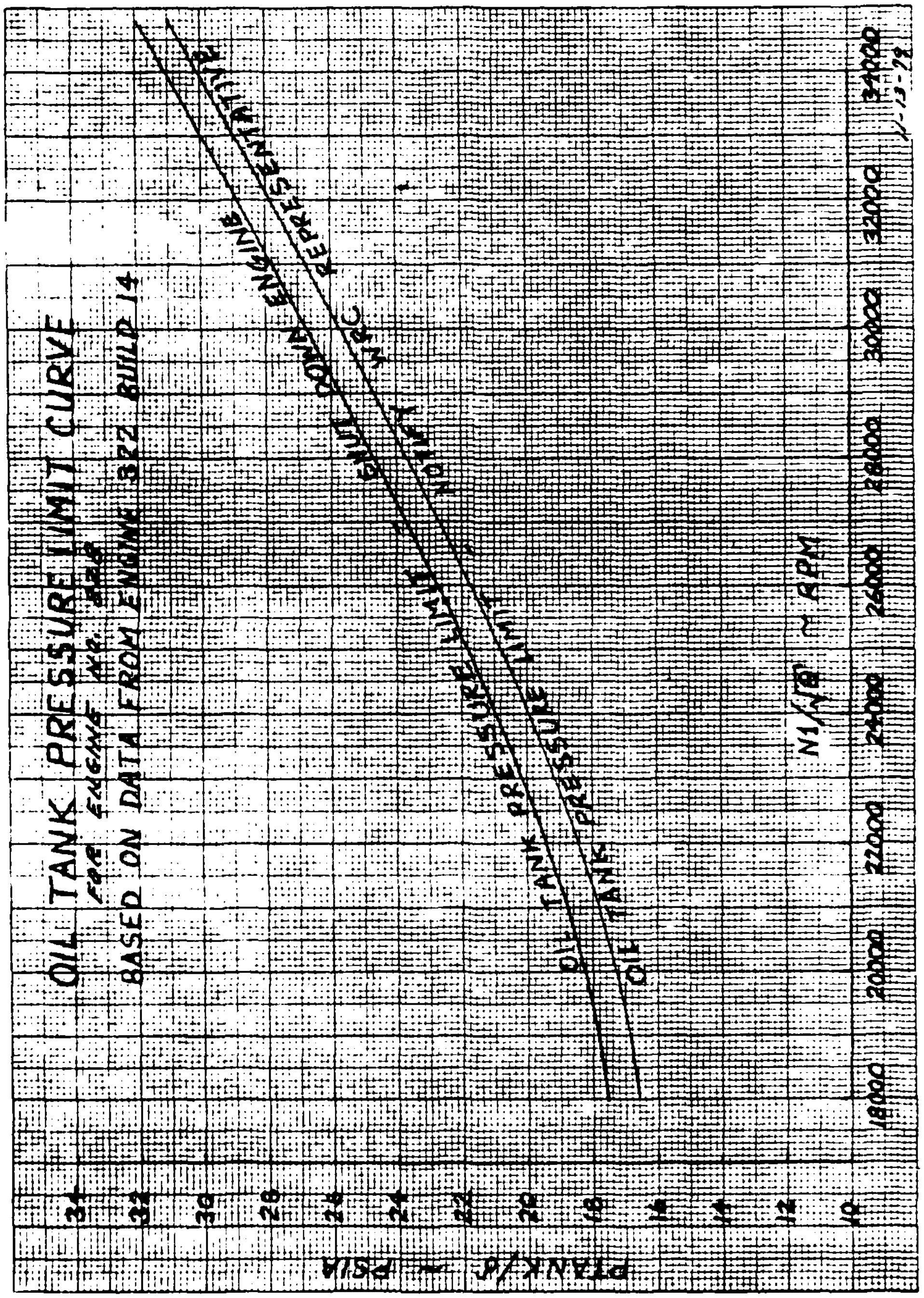
*Bearing temperature limits in Column B are to be compared to the coldest reading when two readings are available.

3. Items 1-2 above are exceptions to paragraph 1.9, <u>Governing Documents</u> of reference A.

mr/mrl

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39



Williams Research Corporation

25 March 1980 CMEP 1-0935

Department of the Air Force
Aeronautical Systems Division
Wright-Patterson Air Force Base
OH 45433

Attention: YZET/Charles Hutcheson

Subject: Transmittal of F107-WR-400 Addendum No. 2 to F107-WR-400 Run Program No. QT21 to Arnold Engineering Development Center AEDC

Gentlemen:

Attached are two copies of "Addendum No. 2 to F107-WR-400 Run Program No. QT21," dated 25 March 1980. This addendum deletes environmental vibration test requirements for engine No. 828-6 to be tested in April 1980. I am forwarding this addendum to you for your review and transmittal of a copy to J. Fergus at AEDC upon your acceptance of it.

Sincerely,

WILLIAMS RESEARCH CORPORATION

F. L. Sole

F. L. Sole
Senior Development Engineer

Richard D Tebay for
R. B. Balsley
Program Manager

mr/ha2

Attachment(s)

cc: Letter and Attachment:

B. Cockshutt
R. Lewis
J. Fergus, AEDC

Letter Only:

P. Wood
B. Beckett
D. Merry
R. Conley

2280 WEST MAPLE ROAD · WALLED LAKE, MICHIGAN · 48088
AREA CODE 313 624-5200 · TWX NO. 810 232-1551

ADDENDUM NO. 2 to F107-WR-400
RUN PROGRAM NO. QT21
25 March 1980

Reference: A. F107-WR-400 Run Program No. QT21, dated 6 November 1979.

B. Addendum No. 1 to F107-WR-400 Run Program No. QT21, dated 15 NOvember 1979.

The purpose of this addendum is to provide further definition to the testing required of engine No. 828-6 during April 1, 1980 through April 15, 1980. The testing is to be performed in its entirety as defined in the above references, including a cartridge start at the beginning of each cycle. Exceptions to the definition are as follows:

1. Paragraphs 1.2.1, 1.3.1, and 4.3 and Item No. 12 on the Test Summary Sheet of Reference A which pertain to the environmental vibration portion of the qualification test are deleted.

2. Item No. 1 of this addendum is an exception to paragraph 1.9 Governing Documents of Reference A.

mr/ha2

Williams Research Corporation

9 April 1980

CMEP 1-0951

Department of the Air Force
Aeronautical Systems Division
Wright Patterson Air Force Base
Ohio 45433

Attention: YZET/Charles Hutcheson

Subject: Transmittal of F107-WR-400 Addendum No. 3 to F107-WR-400 Run Program No. QT21 to Arnold Engineering Development Center (AEDC)

Gentlemen:

Attached are two copies of "Addendum No. 3 to F107-WR-400 Run Program No. QT21," dated 7 April 1980. This addendum pertains to replacement of the fuel control and continuation of the QT Phase II WR-400 mission simulation test on Engine No. 828 that was terminated on 2 April 1980.

I am forwarding this addendum to you for your review and transmittal of a signed copy to J. Fergus at AEDC upon your acceptance of it.

Sincerely,

WILLIAMS RESEARCH CORPORATION

F. L. Sole

F. L. Sole
Senior Development Engineer

Richard Delbay for

R. B. Balsley
Program Manager

ls/tc2

cc: Letter and Attachment
B. Cockshutt
R. Lewis
J. Fergus, AEDC

Letter Only
P. Wood
B. Beckett
R. Conley

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ADDENDUM NO. 3 to F107-WR-400

Run Program No. QT21

7 April 1980

Reference A: F107-WR-400 Run Program No. QT21, dated 6 November 1979

B: Addendum No. 1 to F107-WR-400 Run Program No. QT21, dated 15 November 1979

C: Addendum No. 2 to F107-WR-400 Run Program No. QT21, dated 25 March 1980

The purpose of this addendum is to provide further definition for the testing of Engine No. 828 currently installed in cell T-5 at AEDC. Testing was terminated on 2 April 1980 due to a lack of engine response when a change of power level was commanded. The fuel control was removed and is to be replaced. The test is to be continued as defined in the above references with the following exceptions.

1. The replacement fuel control and a set of ignitors shall be vibrated on another engine as defined in Paragraph 4.3 of Reference A prior to being installed on Engine No. 828.

2. Upon completing installation of replacement fuel control, the engine is to be started to idle and a leak check performed. Repair leaks as required.

3. After completing Step 2, check engine trim by performing a slow accel to +3.65 VDC PLA or engine operating limits (whichever occurs first). This shall be performed at Reference A test summary sheet Item 16 conditions (SL/0.70 standard day with 5.0 shaft horsepower extraction, bleed, and a clean inlet.)

4. After Step 3, adjust engine trim if necessary (reference A test summary sheet Item 17) to HP Speed = 62,550 $^{+0}_{-100}$ rpm at +3.65 VDC at SL/.70 standard day with 5.0 shaft horsepower extraction, bleed and a clean inlet.

5. After Step 4, perform a three point engine calibration (Reference A test summary sheet Item No. 16 except perform only top three power settings) taking two data points at +3.65 and only one data point at each of the other two power settings.

Addendum No. 3
7 April 1980
Page 2

6. After Step 5, at the same flight condition and engine loads as Step 5, perform a rapid accel - decel from -7.15 to +3.65 to -7.15 VDC PLA with a 60 second stabilization period at +3.65 to ensure speed at +3.65 is repeatable (within ±75 RPM of trim speed). Adjust engine trim accordingly if required until speed is repeatable.

7. After Step 6, replace ignitors with those that were vibrated in Step 1. Also inspect engine for fuel and oil leaks and repair leaks. If repairs are required, perform a check run after completing the repairs (Item 24 of Reference A test summary sheet).

8. After Step 7, perform a final leak inspection if a check run was performed and service oil system if no further check runs are required. (Item 25 of Reference A test summary sheet.)

9. After Step 8, perform the mission simulation test as defined in the above references from reference A test summary sheet Item 27 through 41 except a compressed air crank start in Item 27 shall be made instead of a cartridge start since a cartridge start was already performed for that item on 2 April 1980.

10. Steps 1 through 9 of this addendum are exceptions to Paragraph 1.9 Governing Documents of reference A.

ls/mb2

APPENDIX C

DEVIATIONS AND WAIVERS

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 28 June 1978

PROCURING ACTIVITY NO:

1. ORIGINATOR NAME AND ADDRESS: Williams Research Corporation, 2280 W. Maple Rd., Walled Lake, MI 48088	2. [X] DEVIATION [ ] WAIVER	3. [ ] MINOR [X] MAJOR [ ] CRITICAL	

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO	5. BASE LINE AFFECTED	6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED
See Blk 6	24235	See Blk 6	D-002	[ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT	[X] YES [ ] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN	MFR. CODE	SPEC./DOC. NO.	SCN	8. DRAWINGS AFFECTED MFR. CODE	NUMBER	REV.	NOR. NO.
a. SYSTEM							
b. ITEM							
c. TEST PLAN		N/A			N/A		

9. TITLE OF DEVIATION/WAIVER: Substitute nickle plated conduit assemblies to meet corrosion resistance requirements

10. CONTRACT NO. & LINE ITEM: N00019-78-C-0206 CLIN

11. CONFIGURATION ITEM NOMENCLATURE	12. CD NO.	13. DEFECT NO.	14. DEFECT CLASSIFICATION
Engine, Turbofan, F107-WR-(noted)	N/A	N/A	[ ] MINOR [X] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED	16. PART NO. OR TYPE DESIG.	17. LOT NO.	18. QTY	19. RECURRING DEVIATION/WAIVER
Fuel Control, Main Turbine Engine	23850&23860	N/A	102	[ ] YES [X] NO

20. EFFECT ON COST/PRICE	21. EFFECT ON DELIVERY SCHEDULE
To Be Negotiated	See Block 24

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.

None

23. DESCRIPTION OF DEVIATION/WAIVER

Reference: Woodward Governor: Request for Deviation No. WG-D-002

Woodward Governor Company, supplier of the F107 CME Main Fuel Control Units, WRC P/N 23850 and 23860, requests approval to rework their Conduit Assy, P/N 5439-062 by applying electroless nickel plating per MIL-C-26-74, Class 1, Grade A (.001 thick) to the two end fittings, reidentify the assembly as P/N 539-70, and substitute for the P/N 5439-066 Conduit as P/N 5439-70, and substitute for the P/N 5439-066 Conduit Assy specified on their 8061-007 and 8061-009 parts lists.

24. NEED FOR DEVIATION/WAIVER

The primary need for the proposed deviation concerns the F107 Component Qualification Phase of the 23850 and 23860 Fuel Control Units which is currently on stop. The 5439-70 Conduit Assy will be a rework of the present 5439-062 Conduit Assy with electroless nickel plating applied to the Type 410 cast and Type 416 wrought stock ends, both of which evidenced corrosion during qualification humidity testing. The action taken to correct the corrosion problem was to change the materials from Type 410 cast and 416 wrought stock to Type 347 stainless steel cast and machined ends.

(continued on Attachment A)

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER

See Attachment A

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE: [signature] / K. Merry — TITLE: [signature] / G.A. Manager

27. APPROVAL/DISAPPROVAL

a. [X] APPROVAL RECOMMENDED — [signature] 6/30/78 — b. [X] APPROVED [ ] DISAPPROVED

c. GOVERNMENT ACTIVITY: DCAS WRC RESIDENCY — SIGNATURE: [signature] — DATE: 29 Apr 79

DD FORM 1 DEC 66 1694

U.S. GOVERNMENT PRINTING OFFICE

ATTACHMENT A

Request for Deviation
No. WRC D-002

BLOCK 4 & 6 DESIGNATION FOR DEVIATION

a. MODEL/TYPE - This deviation is applicable to Engine Models; F107-WR-101, F107-WR-102, and F107-WR-400.

b. SYSTEM DESIGNATION - This deviation is applicable to Systems designated; AGM-86B, AGM-109, and BGM-109.

BLOCK 24 NEED FOR DEVIATION (continued)

The secondary need concerns continuation of the FCU Component Qualification Test (currently on stop) and utility of available hardware.

Complete conduit assemblies and end fittings of Type 410 and Type 416 stainless steel are available for rework for all the FCU's presently on order. The electroless nickel will provide the corrosion protection required by the specification. Interchangeability is not affected.

Approval to implement the rework and use of existing hardware will permit resumption of component qualification testing and deliveries without further schedule delays, and thus provide sufficient lead time to accomplish the incorporation of Type 347 corrosion resistant stainless steel end fitting for subseqnent production follow-on.

BLOCK 25 PRODUCTION EFFECTIVITY BY SERIAL NO.

F107-WR-101	S/N E000321 thru E000342
F107-WR-102	S/N E000101 thru E000122
F107-WR-400	S/N E000701 thru E000758

JOINT CRUISE MISSILES PROJECT OFFICE
WASHINGTON, D.C. 20360

IN REPLY REFER TO
JCM-850:JR
Ser 823
18 SEP 1978

From: Contracting Officer, Joint Cruise Missiles Project
To: Williams Research Corporation, Walled Lake, MI 48088
Via: DCASO, Williams Research Corporation, Walled Lake, MI 48088

Subj: Contract N00019-78-C-0206, F107 Engine, Deviation - 001 and -002, PCOL-E-78-138

1. Subject deviations have been reviewed and are approved contingent upon WRC's acceptance of the cost/price which is "to be negotiated" at not greater than zero cost to the Government.

[illegible] R. RICE, MAJOR, USAF
Contracting Officer
Joint Cruise Missiles Project

Copy to:
WPAFB (ASD/YZ107)
Local WRC Rep

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 20 April 1979

PROCURING ACTIVITY NO.:

1. NAME AND ADDRESS:
Williams Research Corporation
2280 W. Maple Road, Walled Lake, MI 48088

2. [X] DEVIATION [ ] WAIVER

3. [ ] MINOR [X] MAJOR [ ] CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO.
*	24235	*	D-014R1

5. BASE LINE AFFECTED: [ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT

6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED: [ ] YES [X] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN

	MFR. CODE	SPEC./DOC. NO.	SCN
a. SYSTEM		N/A	
b. ITEM			
c. TEST PLAN			

8. DRAWINGS AFFECTED

MFR. CODE	NUMBER	REV.	NOR. NO.
	N/A		

9. TITLE OF DEVIATION/WAIVER: Substitution of Solid Raw Material

10. CONTRACT NO. & LINE ITEM: N00019-78-C-0206 CLIN 0002AA

11. CONFIGURATION ITEM NOMENCLATURE: Turbofan Engine

12. CD NO.: N/A

13. DEFECT NO.: N/A

14. DEFECT CLASSIFICATION: [ ] MINOR [X] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED: Gas Start Conn. Block

16. PART NO. OR TYPE DESIG.: 34829

17. LOT NO.: N/A

18. QTY: 20

19. RECURRING DEVIATION/WAIVER: [ ] YES [X] NO

20. EFFECT ON COST/PRICE: At No Change in Estimated Cost & Fee

21. EFFECT ON DELIVERY SCHEDULE: See Block 24

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.: N/A

23. DESCRIPTION OF DEVIATION/WAIVER

Allow parts to be fabricated to casting print requirements, except use (347 SST), 03-221 (Plate, Sheet & Strip) or (03-222 (Bars, Wire), in lieu of configured casting, (347 SST) 03-241 (Investment Casting).

*4a;	XF107-WR-400	*4c;	BGM-109
	XF107-WR-102		AGM-109
	XF107-WR-101		AGM-86B

24. NEED FOR DEVIATION/WAIVER

Lead time for investment castings will not support initial pyrotechnic development schedule requirements.

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER

XF107-WR-400 (S/N 826 - 834), XF107-WR-102 (S/N 200 & 201), XF107-WR-101 (S/N 400 & 401)

26. ORIGINATING ACTIVITY AUTHORIZING SIGNATURE / TITLE

27. APPROVAL/DISAPPROVAL

a. [ ] APPROVAL RECOMMENDED

b. [ ] APPROVED [ ] DISAPPROVED

c. GOVERNMENT ACTIVITY | SIGNATURE | DATE

DD FORM 1694

U. S. GOVERNMENT PRINTING OFFICE

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 2November 1979

PROCURING ACTIVITY NO.:

1. ORIGINATOR NAME AND ADDRESS
Williams Research Corporation
2280 W. Maple Rd., Walled Lake, MI 48088

2. [X] DEVIATION [ ] WAIVER

3. [ ] MINOR [XX] MAJOR [ ] CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO.
See Attach A	24235	See Attach A	D-051

5. BASE LINE AFFECTED: [ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT

6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED: [ ] YES [X] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN

[redacted]	MFR. CODE	SPEC./DOC. NO.	SCN
a. SYSTEM			
b. ITEM		N/A	
c. TEST PLAN			

8. DRAWINGS AFFECTED

MFR. CODE	NUMBER	REV.	NOR NO.
24235	23696		–

9. TITLE OF DEVIATION/WAIVER
Spark Ignitor Traceability

10. CONTRACT NO. & LINE ITEM
N00019-78-C-0206
CLIN (See Attach A)

11. CONFIGURATION ITEM NOMENCLATURE
Turbofan Engine

12. CD NO.: N/A
13. DEFECT NO.: N/A
14. DEFECT CLASSIFICATION: [ ] MINOR [XX] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED
Engine Assembly

16. PART NO. OR TYPE DESIG.: See Attach A
17. LOT NO.: N/A
18. QTY: 64
19. RECURRING DEVIATION/WAIVER: [X] YES W-102 [ ] NO

20. EFFECT ON COST/PRICE
No Effect

21. EFFECT ON DELIVERY SCHEDULE
None

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.
No Effect

23. DESCRIPTION OF DEVIATION/WAIVER

Allow use of serialized, nontraceable ignitors in engines remaining under the FSD Program.

24. NEED FOR DEVIATION/WAIVER

The vendor, Champion Spark Plug Co., has notified Williams Research that they will not provide traceability for their igniters. The vendor states that it would be difficult to undertake a traceability system for just one igniter type and that their present inspection system combined with the testing required by the WRC igniter procurement specification is sufficient to supply a quality product.

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER
See Attachment A

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE / TITLE
Philip E. Hood — Ch. Dev. Eng. — Director Quality

27. APPROVAL/DISAPPROVAL

a. [X] APPROVAL RECOMMENDED
b. [X] APPROVED [ ] DISAPPROVED

c. GOVERNMENT ACTIVITY
J. Kelley DCAS-WRC

SIGNATURE: David D. McClelland
Administrative Contracting Officer

DATE: 19 Nov 79

DD FORM 1694

U.S. GOVERNMENT PRINTING OFFICE

ATTACHMENT A
D-051

BLOCK 24: PRODUCTION EFFECTIVITY BLOCK 4a/4c/10/16

MODEL/TYPE	SYS DESIG	ENG P/N	CLIN	ENG S/N
XF107-WR-101	AGM-86B	1022951-106	0002AA	325
XF107-WR-101	AGM-86B	1022951-109	0002AA	1, (TBD)
XF107-WR-101	AGM-86B	1022951-110	0006AK	326
XF107-WR-101	AGM-86B	1022951-111	0002AA	400 - 402
XF107-WR-101	AGM-86B	1022951-115	0012AA	326
XF107-WR-102	AGM-109	1023700-102	0002AA	105
XF107-WR-102	AGM-109	1023700-108	0002AA	1, (TBD)
XF107-WR-102	AGM-109	1023700-109	0002AA	200 - 202
YF107-WR-102	AGM-109	1023700-111	0002AN	122'
XF107-WR-400	BGM-109	1029110-107	0012AA	706
XF107-WR-400	BGM-109	1029110-100	0002AJ	815
XF107-WR-400	BGM-109	1029110-106	0002AA	1, (TBD)
XF107-WR-400	BGM-109	1029110-108	0002AA	826 - 829
XF107-WR-400	BGM-109	1029110-111	0012AA	706
YF107-WR-400	BGM-109	1029110-100	0002AC	814
YF107-WR-400	BGM-109	1029110-101	0002AC	722
YF107-WR-400	BGM-109	1029110-109	0002AC	723 - 756
YF107-WR-400	BGM-109	1029110-110	0002AC	816 - 822

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 10 November 1978

PROCURING ACTIVITY NO.:

1. ORIGINATOR NAME AND ADDRESS
Williams Research Corporation
2280 W. Maple Rd., Walled Lake, MI 48088

2. [ ] DEVIATION [X] WAIVER

3. [ ] MINOR [X] MAJOR [ ] CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO.
*	24235	*	W-036

5. BASE LINE AFFECTED: [ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT

6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED: [ ] YES [X] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN

	MFR. CODE	SPEC./DOC. NO.	SCN
a. SYSTEM			
b. ITEM			
c. TEST PLAN		N/A	

8. DRAWINGS AFFECTED

MFR. CODE	NUMBER	REV.	NOR. NO.
	*		

9. TITLE OF DEVIATION/WAIVER
Waive Bearing Traceability Requirements

10. CONTRACT NO. & LINE ITEM
N00019-78-C-0206
CLIN 0002AB

11. CONFIGURATION ITEM NOMENCLATURE
See Attachment A

12. CD NO.: N/A

13. DEFECT NO.: N/A

CLASSIFICATION OF DEFECT

14. DEFECT CLASSIFICATION: [ ] MINOR [X] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED
Bearing

16. PART NO. OR TYPE DESIG.: *

17. LOT NO.: N/A

18. QTY: *

19. RECURRING DEVIATION/WAIVER: [ ] YES [X] NO

20. EFFECT ON COST/PRICE
To be negotiated

21. EFFECT ON DELIVERY SCHEDULE
None

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.
None

23. DESCRIPTION OF DEVIATION/WAIVER

Allow use of bearing listed on Attachment A. These bearings are serialized, but do not have full traceability.

*See Attachment A

24. NEED FOR DEVIATION/WAIVER

The bearings were purchased with no traceability requirements. Subsequently, the Government directed WRC to provide fully traceable bearing, a requirement which can not be met with current engine test and delivery schedules. All bearings purchased after this lot of bearings shall have full traceability or, at the Governments request, this requirement would be dropped.

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE
11-10-78 Donald McNerney

TITLE
Prog. Mgr. Dir. Qual. Assurance

27. APPROVAL/DISAPPROVAL

a. [X] APPROVAL RECOMMENDED 11/13/78 James B. Biedesler
c. GOVERNMENT ACTIVITY
DCAS-WRC Residency

b. [X] APPROVED [ ] DISAPPROVED

SIGNATURE
David H. McClelland

DATE
17 Nov 1978

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U. S. GOVERNMENT PRINTING OFFICE

10 November 1978
WRC Waiver W-036
ATTACHMENT A

Blocks 8, 16 & 18 BEARINGS AT WRC (RECEIVING INSPECTION)
OR DUE TO BE RECEIVED

P/N	Date	Vendor	PO	Amt	Date Rec'd	Chg Ltr	WRC Spec
27099	3/29/77	MRC	91818	263	9/5	A	P-7420
27099	3/10/78	MRC	99864	68	8/21	A	P-7420
27099	11/11/77	MRC	97022	77	3/17	A	P-7420
29056	11/21/77	BARDEN	97039	99	7/20	NC	P-7410
29056	11/21/77	BARDEN	97040	10	7/26	NC	P-7410
19301	4/13/77	MRC	91849	44	4/5/78	B	P-7410
19301	10/4/77	MRC	96302	288	3/21/78	B	P-7410
19301	11/12/77	MRC	97023	65		B	P-7410
22988	11/12/77	MRC	97024	78	7/11	NC	P-7410
23372	12/11/77	FAFNIR	97095	20	9/6	NC	P-7420
29056	11/21/77	BARDEN	97039	99	7/20/78		P-7410
29056	11/21/77	BARDEN	97040	35	8/18/78		P-7410
27100	1/21/77	MRC	89108	7	7/20/78		P-7420
27066	3/17/78	BARDEN	99892	9	6/12/78		P-7420
29477	10/14/77	BARDEN	99332	70	5/24/78		P-7420
29477	10/26/77	BARDEN	96377	10	7/25/78		P-7420
29651	2/13/78	BARDEN	98565	52	8/25/78		P-7410
29652	10/22/77	BARDEN	96359	75	6/15/78		P-7410
29845	12/12/77	BARDEN	97083	25	8/31/78		P-7420
27099	6/15/76	MRC	83310	3	8/31/78		P-7420
27099		MRC	89107	4	8/31/78		P-7420
27099	11/11/77	MRC	97022	33	8/31/78		P-7420
27100	11/11/77	MRC	97021	75	8/31/78		P-7420
22098	9/19/77	SPLIT BB	94280	65	8/21/78		P-7420
22098	3/25/77	SPLIT BB	91813	5	8/21/78		P-7420
23383	2/6/78	SPLIT BB	98626	25	9/1/78		P-7420
22988	11/12/77	MRC	97024	13			P-7410
22098	11/17/77	SPLIT BB	97030	25			P-7420
23371	1/23/78	FAFNIR	98578	20			P-7410
23410	1/25/78	NEW HAMPSHIRE	98610	50			P-7420
29843	2/1/78	NEW HAMPSHIRE	98611	20			P-7420

BLOCK A: XF107-WR-400
YF107-WR-400
XF107-WR-101
YF107-WR-101
XF107-WR-102
YF107-WR-102

BLOCK C: BGM-109
AGM-86A
AGM-109

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 24 January 1979

PROCURING ACTIVITY NO.:

1. ORIGINATOR NAME AND ADDRESS
Williams Research Corporation
2280 W. Maple Rd., Walled Lake, MI 48088

2. [ ] DEVIATION [X] WAIVER

3. [ ] MINOR [X] MAJOR [ ] CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO.
*	24235	*	W-042

5. BASE LINE AFFECTED: [ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT

6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED: [ ] YES [X] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN

[redacted]	MFR. CODE	SPEC./DOC. NO.	SCN
a. SYSTEM			
b. ITEM		N/A	
c. TEST PLAN			

8. DRAWINGS AFFECTED

MFR. CODE	NUMBER	REV.	NOR. NO.
	N/A		

9. TITLE OF DEVIATION/WAIVER
Waive Bearing Traceability Requirements

10. CONTRACT NO. & LINE ITEM
See Attachment A

11. CONFIGURATION ITEM NOMENCLATURE
See Attachment A

12. CD NO.: N/A

13. DEFECT NO.: N/A

CLASSIFICATION OF DEFECT
14. DEFECT CLASSIFICATION: [ ] MINOR [X] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED: Bearing

16. PART NO. OR TYPE DESIG.: *

17. LOT NO.: N/A

18. QTY: *

19. RECURRING DEVIATION/WAIVER: [ ] YES [X] NO

20. EFFECT ON COST/PRICE
None

21. EFFECT ON DELIVERY SCHEDULE
None

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.
None

23. DESCRIPTION OF DEVIATION/WAIVER

Allow use of bearing listed on Attachment A. These bearings are serialized, but do not have full traceability.

See Attachment A

Ref: WRC-W-036

24. NEED FOR DEVIATION/WAIVER

The bearings were purchased with no traceability requirements. Subsequently, the Government directed WRC to provide fully traceable bearing, a requirement which can not be met with current engine test and delivery schedules. All bearings purchased after this lot of bearings shall have full traceability or, at the Governments request, this requirement would be dropped.

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER
FSD Engines as allocated to stock depletion.

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE: [signature]

TITLE: Prgm Mgr

27. APPROVAL/DISAPPROVAL

a. [X] APPROVAL RECOMMENDED: J Kelly

b. [X] APPROVED [ ] DISAPPROVED

c. GOVERNMENT ACTIVITY: DCAS - WRC 2/26/79

SIGNATURE: [signature]

DATE: 26 Feb 79

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U. S. GOVERNMENT PRINTING OFFICE 1969 O - 135-091

ATTACHMENT A
W-042

BLOCK 23: DESCRIPTION OF DEVIATION/WAIVER

Waiver 036 was approved 17 November 1978 permitting the use of bearings which were serialized but did not have full traceability. At the time of submittal, we thought we had accounted for all contingencies. However, we have located 5 lots in MRB and have been informed by one of our vendors that they have 2 lots for delivery made from parts overrun of a previously delivered order. The particulars are as follows:

A. BEARINGS ROUTED TO MRB

P/N	VENDOR	P.O.	AMT	DATE REC'D	WRC SPEC
27100	MRC	73112	22	8/26/77	P-7420
27100*	MRC	89108	7	8/12/78	P-7420
27100*	MRC	89108	3	9/7/78	P-7420
27099*	MRC	83310 73112	114	8/26/77	P-7420
27099*	MRC	83310	48	8/26/77	P-7420
27099	MRC	99864	68	8/21/78	P-7420
27099	MRC	99864	47		P-7420

B. BEARINGS FROM OVERRUN PARTS

P/N	DATE	VENDOR P.O.	AMT	DATE REC'D	CHG LTR	WRC SPEC
27075	5/2/78	Barden 101847	20	---	C	P-7420
27066	5/2/78	Barden 101848	11	---	C	P-7420

* These bearings not serialized will be returned to vendor for serialization.

BLOCK 10: CONTRACT NO. AND LINE ITEM

N00019-78-C-0206

CLIN 0002AA	CLIN 0002AE	CLIN 0002AM
0002AB	0002AH	0002AN
0002AC	0002AK	0002AR
0002AD	0002AL	

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED: 5 July 1979

PROCURING ACTIVITY NO.:

1. ORIGINATOR NAME AND ADDRESS: Williams Research Corporation, 2280 W. Maple Rd., Walled Lake, MI 48088

2. [ ] DEVIATION [X] WAIVER

3. [ ] MINOR [X] MAJOR [ ] CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEV/WAIVER NO.
See Blk 23	24235	See Blk 23	W-090C1

5. BASE LINE AFFECTED: [ ] FUNCTIONAL [X] ALLOCATED [ ] PRODUCT

6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED: [ ] YES [X] NO

7. SPECIFICATIONS AFFECTED-TEST PLAN

	MFR. CODE	SPEC./DOC. NO.	SCN
a. SYSTEM			
b. ITEM		N/A	
c. TEST PLAN			

8. DRAWINGS AFFECTED

MFR. CODE	NUMBER	REV.	NOR. NO.
	N/A		

9. TITLE OF DEVIATION/WAIVER: Traceability of Oil Coolers

10. CONTRACT NO. & LINE ITEM: N00019-78-C-0206 CLIN (noted)

11. CONFIGURATION ITEM NOMENCLATURE: Turbofan Engine

12. CD NO.: N/A

13. DEFECT NO.: N/A

14. DEFECT CLASSIFICATION: [ ] MINOR [X] MAJOR [ ] CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED: Oil Cooler

16. PART NO. OR TYPE DESIG.: 23748

17. LOT NO.: N/A

18. QTY: 18

19. RECURRING DEVIATION/WAIVER: [ ] YES [X] NO

20. EFFECT ON COST/PRICE: None

21. EFFECT ON DELIVERY SCHEDULE: N/A

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.: N/A

23. DESCRIPTION OF DEVIATION/WAIVER

Allow use of P/N 23748 oil coolers listed on Attachment A. These oil coolers are serialized, but do not offer full traceability.

(see Attachment A)

(Ref: IRR #80786)

24. NEED FOR DEVIATION/WAIVER

(see Attachment A)

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER: See Block 23

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE: [signature] — TITLE: Ch. Dev. Engr. [illegible]

27. APPROVAL/DISAPPROVAL

a. [X] APPROVAL RECOMMENDED [signature]

b. [X] APPROVED [ ] DISAPPROVED — S/N [illegible] NOTE [illegible]

c. GOVERNMENT ACTIVITY: DPRO URC 7/5/79

d. SIGNATURE: David N. McClellan — Administrative Contracting Officer — DATE: 5 July 1979

DD FORM 1 DEC 68 1694

U.S. GOVERNMENT PRINTING OFFICE

ATTACHMENT A
W-090C1

BLOCK 23: DESCRIPTION (continued)

S/N TT5791297H TT5791292H
TT5791900H TT5791286H
TT5791290H TT5791291H
TT5791287H TT5791293H
TT5791901H TT5791905H
TT5791296H TT5791289H
TT5791294H TT5791903H
TT5791904H TT5791288H
TT5791902H TT5791295H

MODEL NO.	SYSTEMS DESIGN	CLIN
XF107-WR-102	AGM-109	0002AA
YF107-WR-102	AGM-109	0002AN, AR
XF107-WR-400	BGM-109	0002AA
YF107-WR-400	BGM-109	0002AC

BLOCK 24: NEED FOR DEVIATION/WAIVER

As a result of a change in the manufacturing source, traceability on the units identified above, was not maintained. These units were in the process of fabrication when Waiver-082* was submitted. At that time, unit S/N's were not available, therefore, it was not possible to include the above 18 units with W-082*.

Midland-Ross/Janitrol, the new supplier, has implemented corrective action for units which will be manufactured completely by them in the future.

* (W-082 traceability of oil coolers)

APPENDIX D

VIBRATION TEST DATA

This appendix is a graphic presentation of data observed during the environmental vibration testing related to Engine 828/builds 4 and 6 at Bendix Aerospace Systems Division - Ann Arbor, Michigan. Two types of curves are presented. One type is the sinusoidal vibration sweeps performed to identify the resonant frequencies to be used for the 30-minute constant level vibration inputs required along the lateral and vertical axes of the F107-WR-400 engine. The second type of plot shown represents the power spectral density (PSD) curves obtained during the 30-minute random frequency vibration inputs along the three major engine axes.

The material presented herein is divided into four sections. The first section contains the specification power spectral density (PSD) curve for the F107-WR-400 engine. This specification curve may be used in evaluating the PSD curves representing the random frequency vibration testing completed on Engine 828. No specification curve exists in reference to the sinusoidal vibration sweeps as these surveys were run primarily to identify test points for the 30-minute constant input level vibration tests.

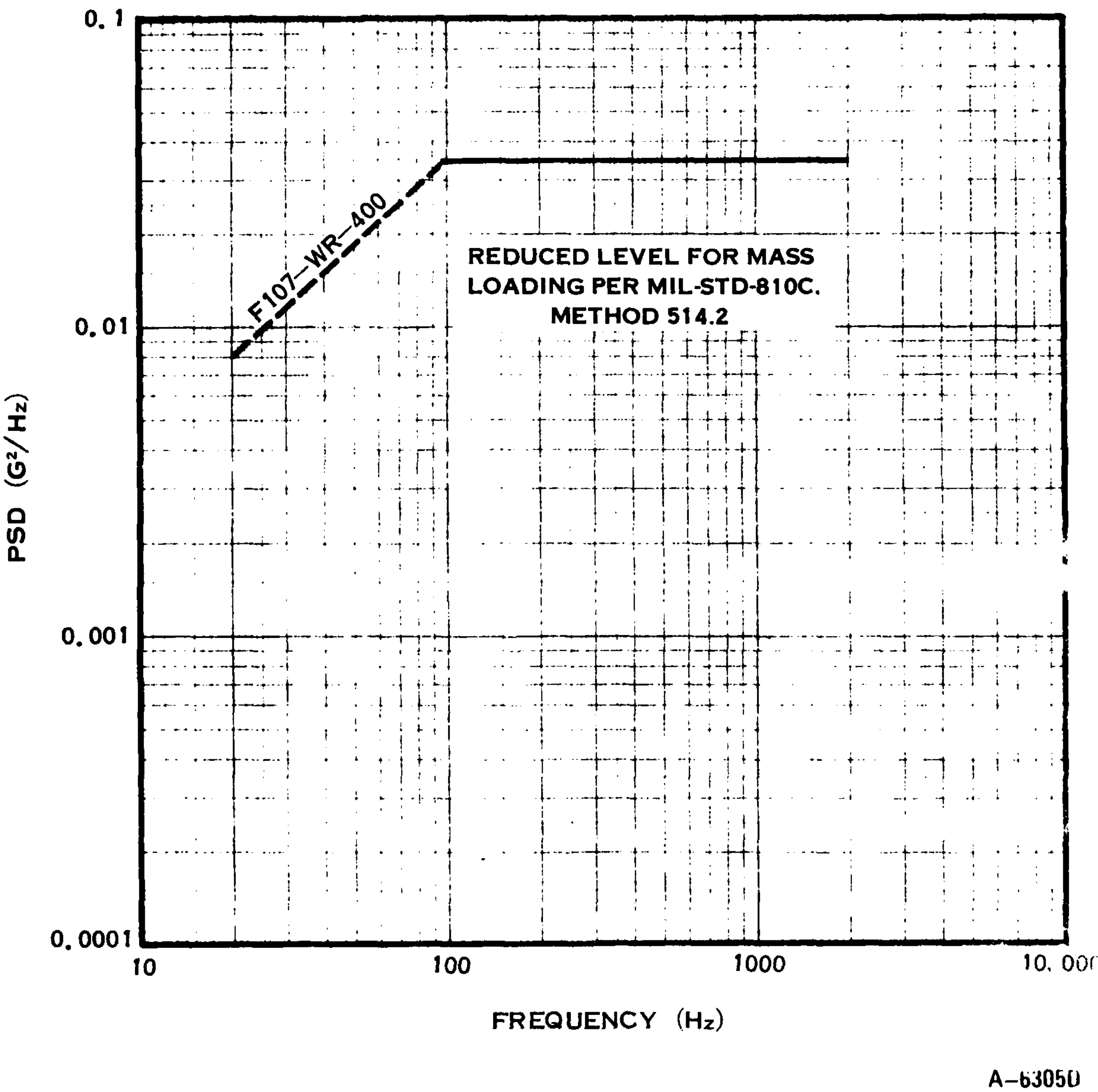
The second section presents a chronology of events and the vibration curves obtained during the initial vibration test series, run on 4 January 1980.

The third section presents a chronology of events and data obtained during the second complete vibration test series performed with Engine 828. This second series was run subsequent to discovery of the fact that the first test series had inadvertently been performed without an airframe generator installed on the engine. It is required that all accessories and components be installed on qualification vibration test engines. This test series was performed on 14 January 1980.

The fourth section is a presentation of events and data curves obtained during the vibration testing of fuel control unit S/N 1443454 (installed on F107-WR-400 Engine 704 as a test vehicle). This fuel control unit was subsequently shipped to AEDC to replace the fuel control unit which had failed on Engine 828 during the hot day mission simulation cycle. The S/N 1443454 unit was subjected to the complete environmental vibration test requirement while at Bendix Aerospace.

SECTION I

SPECIFICATION POWER SPECTRAL DENSITY CURVE
FOR THE F107-WR-400 ENGINE



Random Systems Environment Vibration Envelope

SECTION II

A chronicle of events and the vibration test curves obtained during the initial vibration test series, which was conducted on 4 January 1980.

Williams Research Corporation

CMEP 95-4120
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Bendix Aerospace Systems Division

LR ______
Page 1

TEST SEQUENCE

Test Item WRC ENGINE F107-WR-400 PN ______
Test VIBRATION SN 828 Date 1-4-80
Technician C.F. FOX Test Engineer J.W. ANDERSON

Seq No.	Time of Day	Axis	Test Mode No.	Test Time	Remarks
1	1025	VERT.	1	10 MIN	10-100-10 HZ @ 2.0 g NOTE (1)
2	12:50	"	1	5 MIN	10-100 HZ @ 2.0g PLOTTING TRIAXIAL RESP. ACCEL
3	13:10	"	1	"	" " " PLOTTING INLET HOUSING ACCEL
3A	1350	"	1	7 min 30 SEC	DWELL @ 15 HZ 2.0g
4	1423	"	2	30 MIN	RANDOM PER SPEC. 7.6 gRMS NOTE (2)
	1-5-~~80~~				
5	0820	VERT.	1	5 MIN	10-100 HZ @ 2.0g PLOTTING TRIAXIAL RESPONSE (FILTERED)
6	0840	"	1	5 MIN	10-150 HZ @ 2.0g PLOTTING INLET HOUSING ACCEL (FILTERED)
7	0853	"	1	1 MIN	10-18 HZ @ 2.0g REVERSED TRACKING FILTERS
8	0910	"	1	1 MIN	10-16 HZ @ 2.0g SWITCHED CHARGE AMPLIFIERS
9	1000	"	1	5 MIN	10-100 HZ @ 2.0g INSTALLED ACC ON INLET (1 AXIS) (PLOTTING FILTERED)
10	1010	"	1	5 MIN	" " " " (PLOTTING UNFILTERED)
11	1040	"	1	22 min 30 sec	DWELL AT 15 HZ @ 2.0g FOR COMPLETION OF SEQ 3A
12	1106	"	1	30 min.	DWELL AT 100 HZ @ 2.0g
13	1413	LATERAL	1	10 MIN	10-100-10 HZ @ 2.0g PLOTTING UNFILTERED RESPONSE
					PLOTTED INLET HOUSING ON UPSWEEP & TRIAXIAL ON DOWNSWEEP
14	1440	"	1	30 MIN	DWELL @ 100 HZ 2.0g
15	1515	"	2		RANDOM PER SPEC. 7.6 gRMS
					1-7-80
16	0955	AXIAL	2	30 MIN.	7.7 gRMS PER SPEC. (3)

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Bendix Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

OBSERVED DATA

LR
Page 2

Test: SINE & RANDOM VIBRATION
Test Item: WRC ENGINE F107-WR-400, S/N 828 Test Date 1/4,5,7/80
Technicians: G.E. FOX Approved by: MONROE

Time of Day	
	NOTE 1 NOTED RESONANCE ON CDP TUBE @ 85-90 HZ.
	2 INLET HOUSING ACCEL. 5.2 grms
	TRIAXIAL RESPONSE ACC. 4.1 grms
	3 TRIAXIAL ACC. - 6.5 grms
	INLET HOUSING ACC. - 8.0 grms
	FOR RECORDING RESPONSE ACCEL. DURING SINE TEST, A MOD. SD13I TRACKING FILTER WAS [illegible] FROM WRC TO FILTER OUT RESPONSE DATA. (COURS IN CAL. LAB. FOR REPAIR.)

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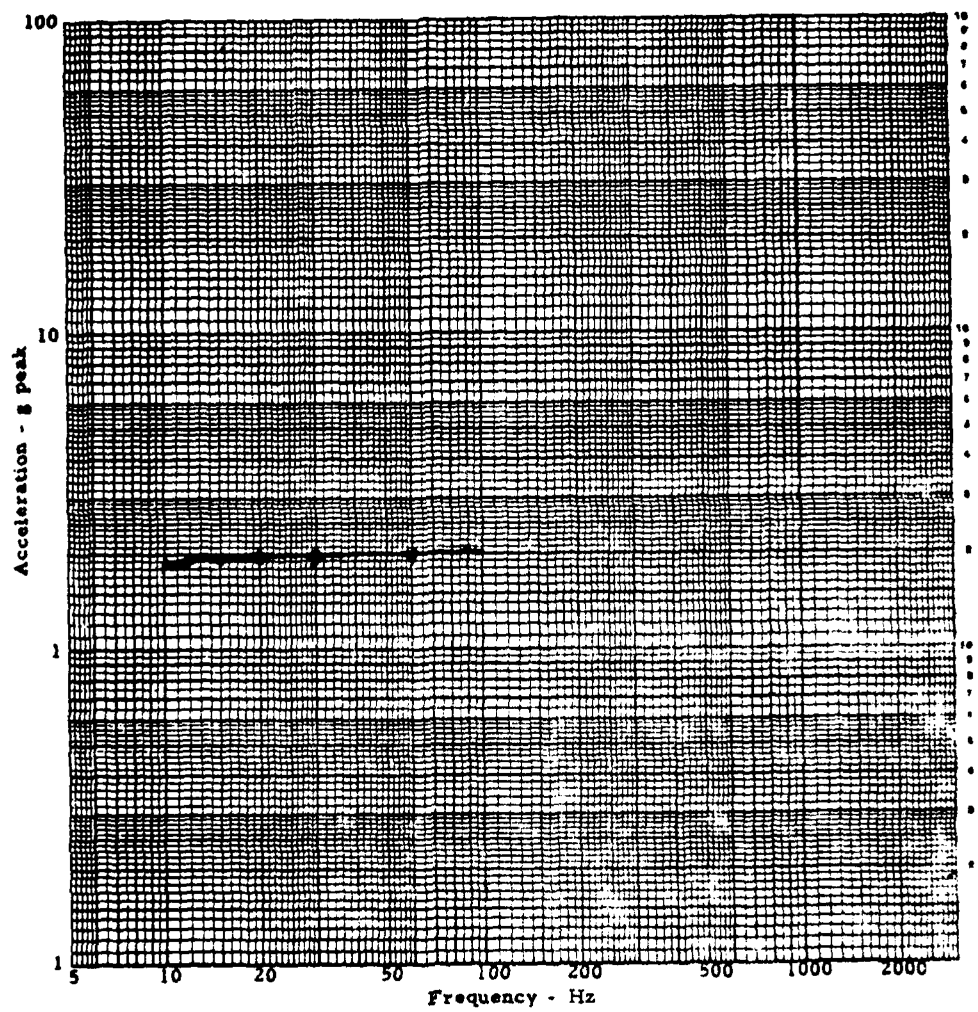
Bendix
Aerospace Systems Operations

TR
FIGURE /

VIBRATION LEVELS

Test Item: W.R.C. ENGINE F107-WR-400
Test Date: 1-4-80

Serial Number: 828
Input Axis: VERT.
Response Axis:



440-8 A

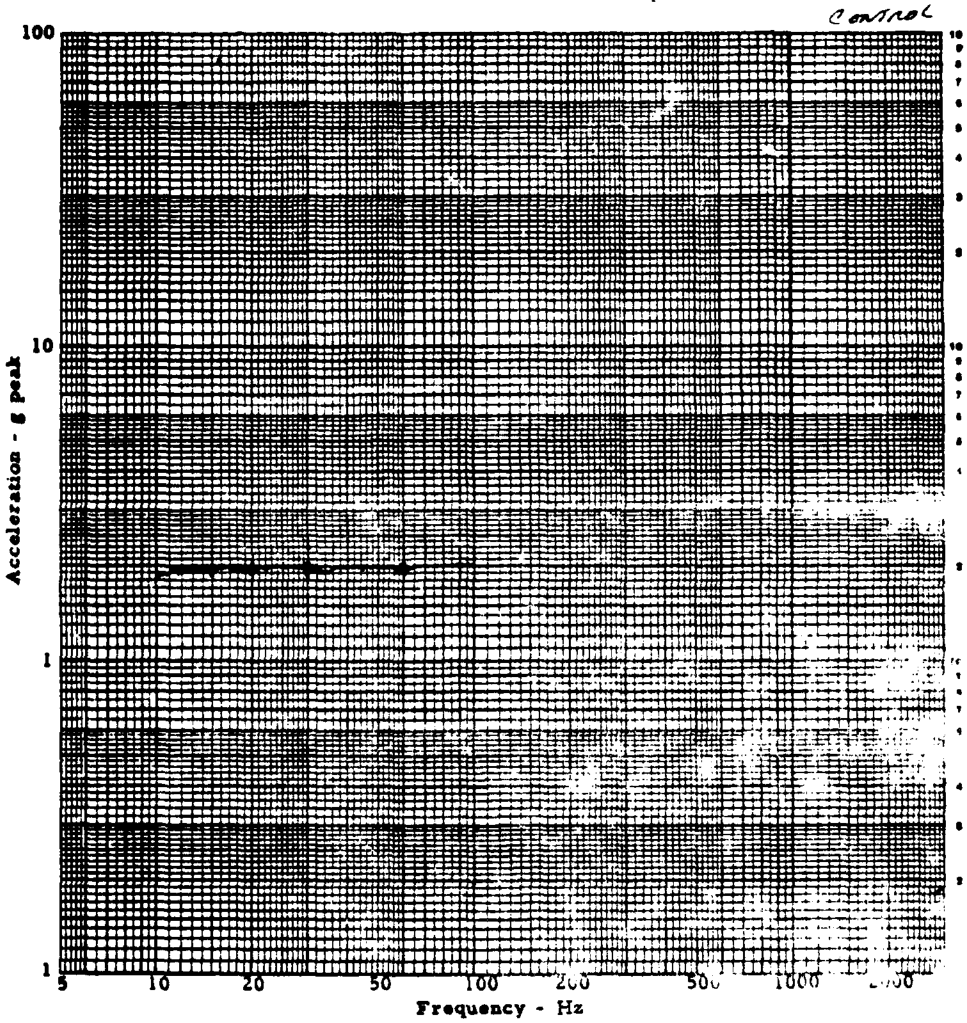
SEQ. 1

Bendix
Aerospace Systems Operations

TR FIGURE 2

VIBRATION LEVELS-INPUT

Test Item: WRC ENGINE F107 WR 400
Test Date: 1-4-80
Serial Number: 828
Input Axis: VERTICAL
~~Response Axis:~~ CONTROL



440-8 A

SER. 2

Bendix
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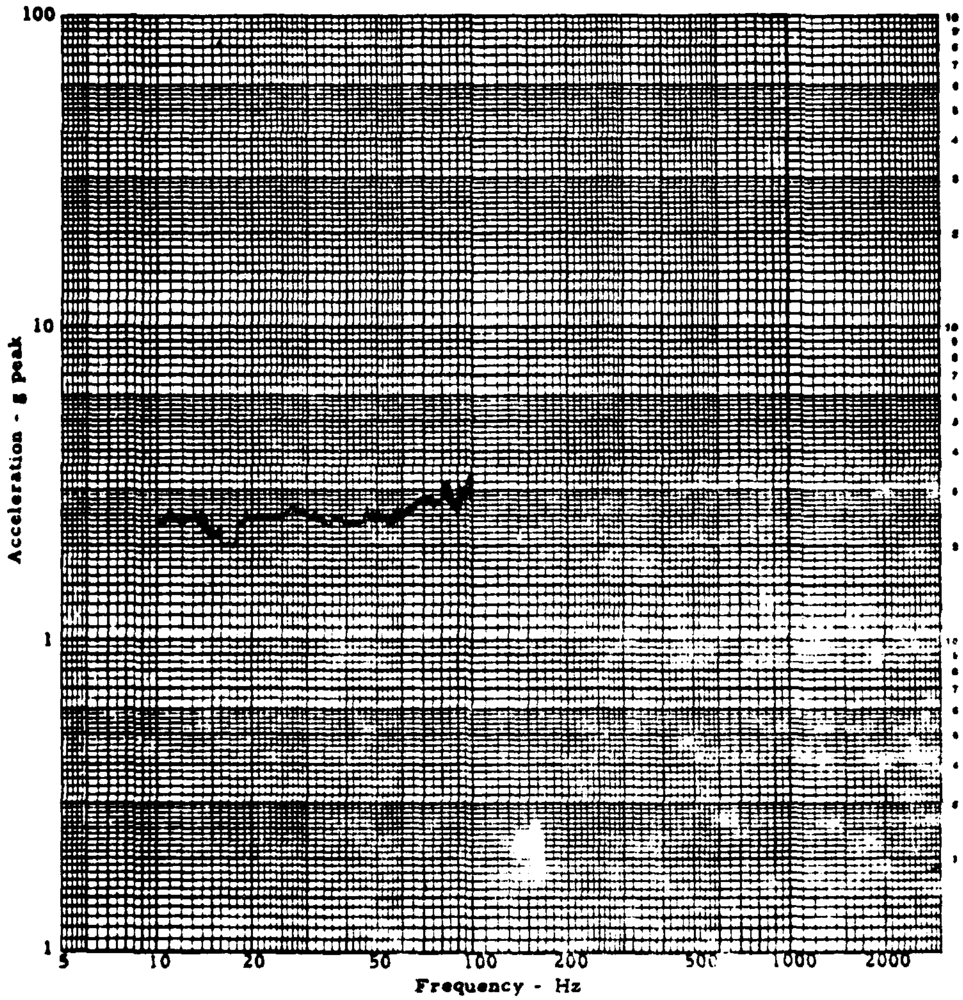
TR
FIGURE 3

VIBRATION LEVELS

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-4-80
Serial Number: 828
Input Axis: VERTICAL - SINE
Response Axis: TRIAXIAL ACCEL.



440-8 A

SEQ 2

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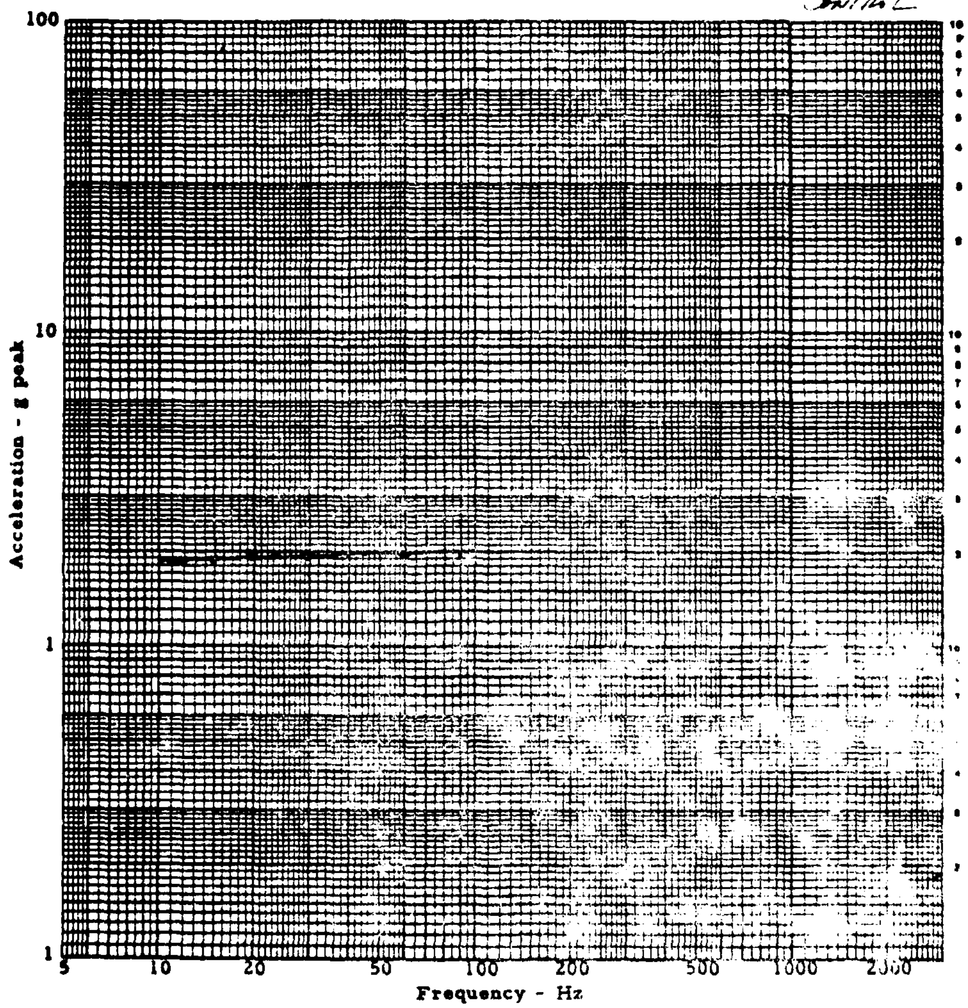
Aerospace Systems Operations

TR
FIGURE 4

VIBRATION LEVELS—INPUT

Test Item: NR ENGINE FIXTURE 400 **Serial Number:** 828
Test Date: 1-4-80 Input Axis: VERT.
~~Response Axis:~~ CONTROL



440-8 A

SEQ. 3

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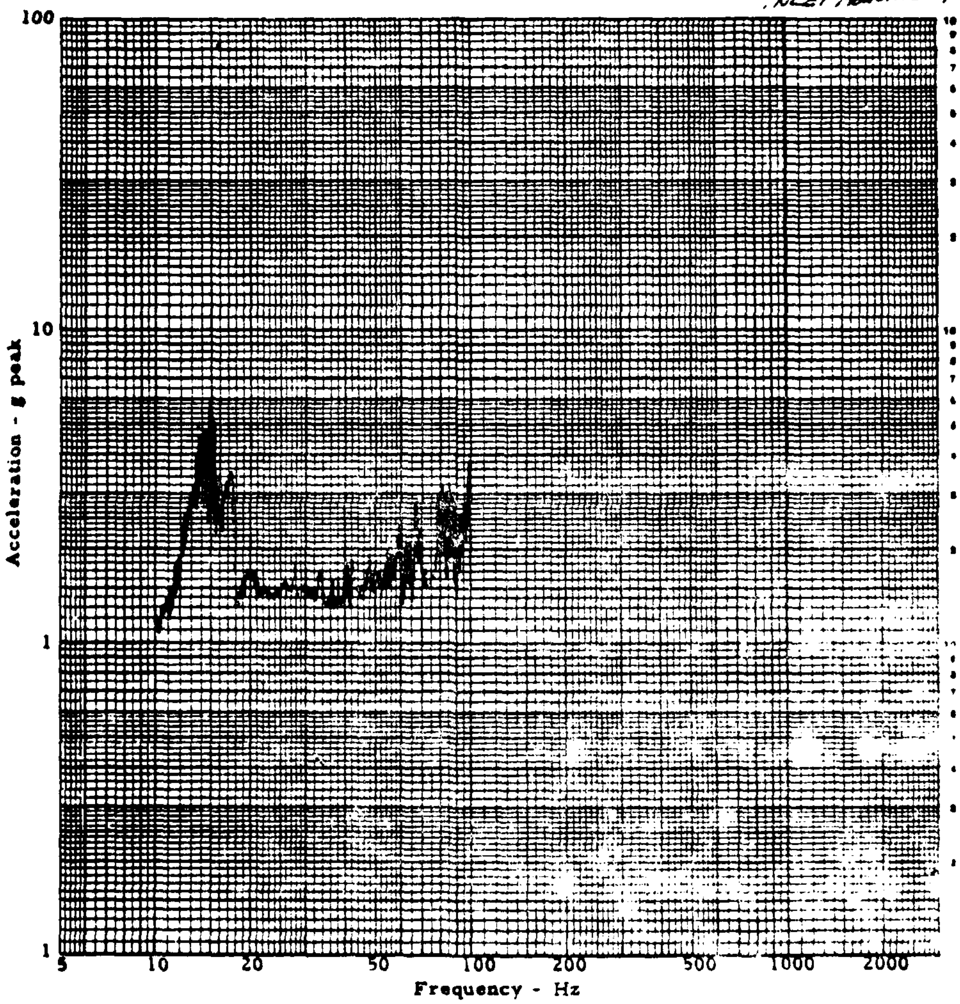
Bendix
Aerospace Systems Operations

TR
FIGURE 5

VIBRATION LEVELS

Test Item: WRC ENGINE F-[illegible]
Test Date: [illegible]-80

Serial Number: F28
Input Axis: VERTICAL - SINE
Response Axis: INLET HOUSING ACCEL



440-8 A

SEQ. 3

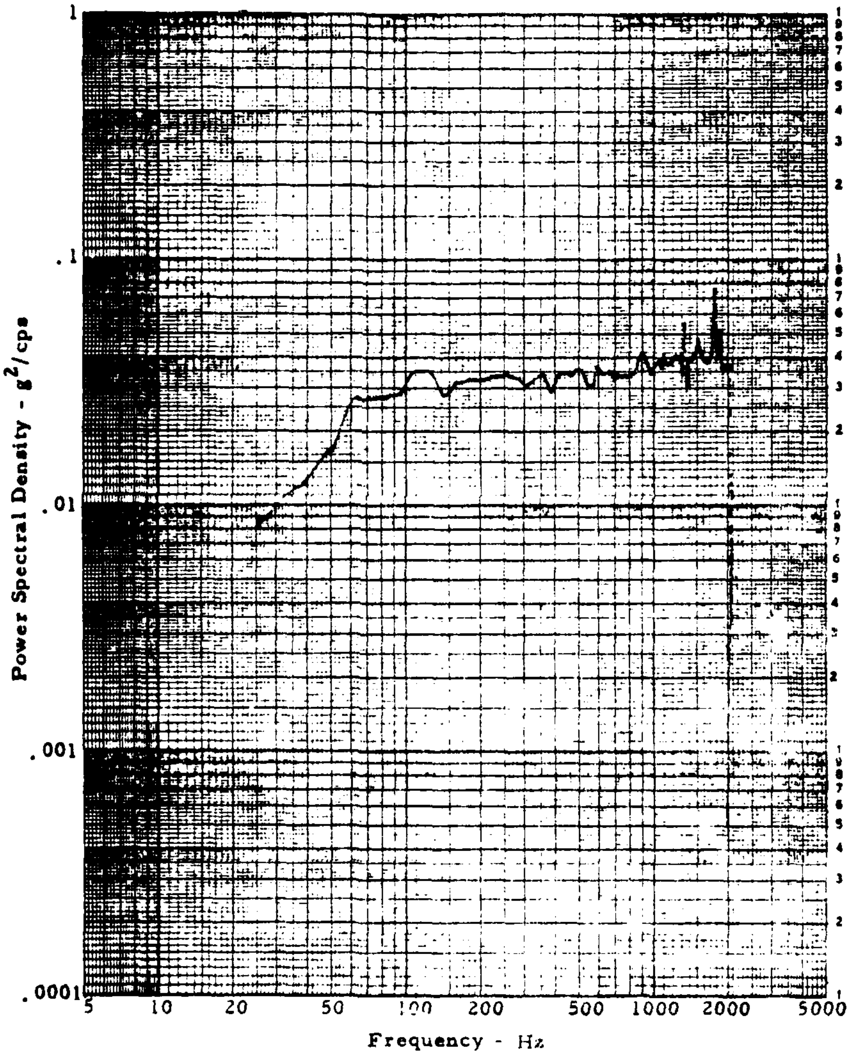
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 6

RANDOM VIBRATION SPECTRUM

Test: QUAL. VIBRATION
Test Item: WRC ENGINE F107-WR-400 SN: 828
Test Date: Axis: VERT



Seq. 4

START of 30 min. TEST

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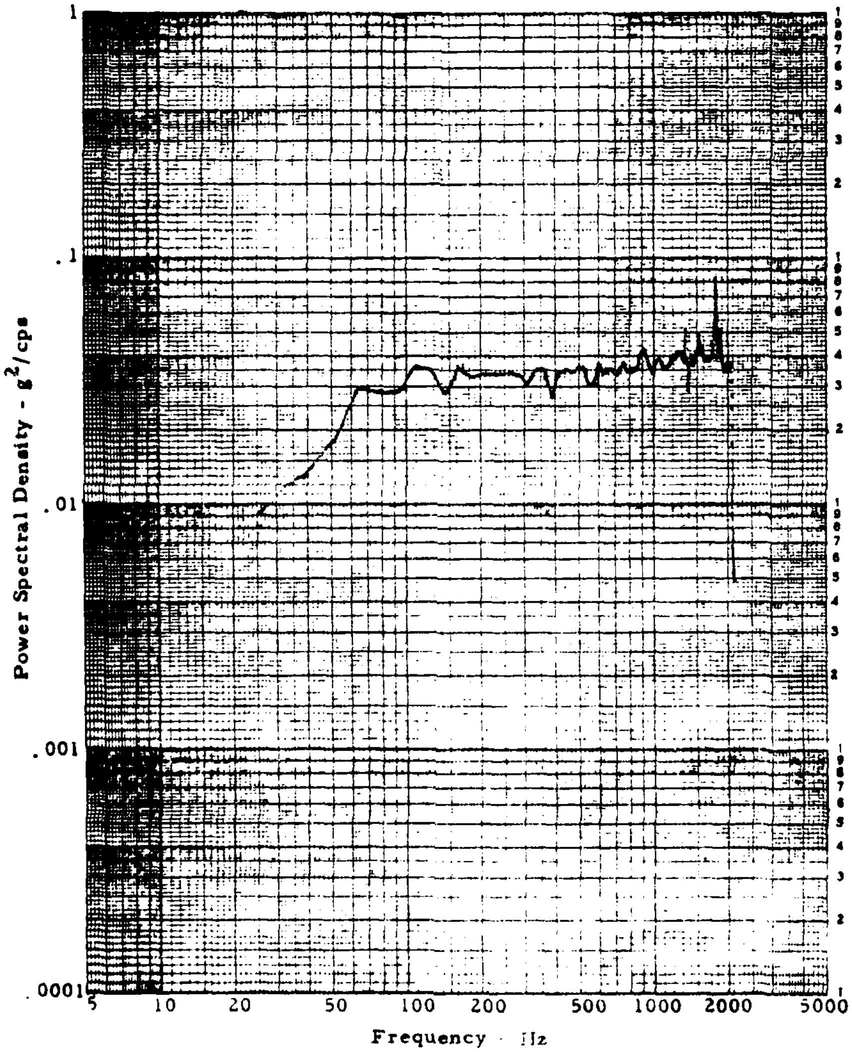
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 7

RANDOM VIBRATION SPECTRUM

Test: QUAL. VIBRATION
Test Item: WRC ENGINE F-107-WR-400 SN: 828
Test Date: 1-4-80 Axis: VERTICAL



440-13A

Seg. 4
END

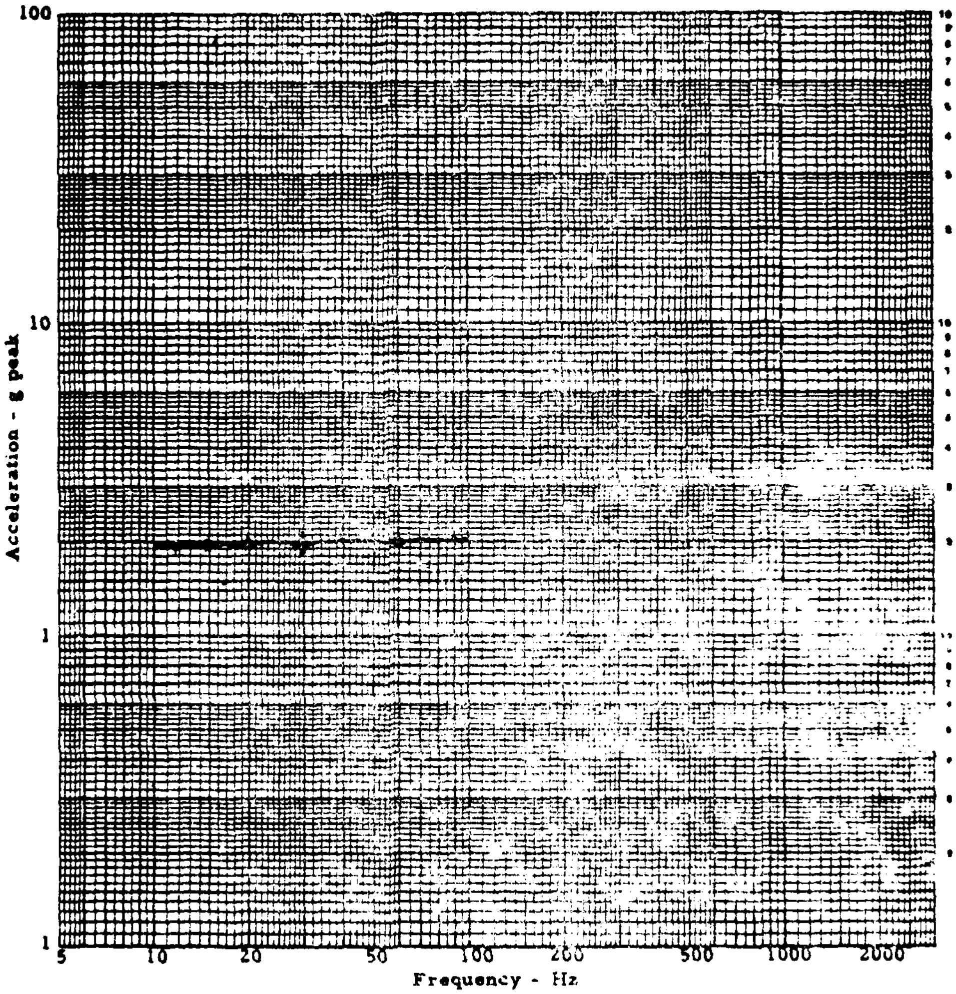
Bendix
Aerospace Systems Operations

TR FIGURE 8

VIBRATION LEVELS - INPUT

Test Item: WRC ENGINE F-107-WR-100
Test Date: 1-5-90

Serial Number: 828
Input Axis: VERTICAL - SINE
~~Response Axis~~:



440-8 A

SEQ.5

Williams Research Corporation

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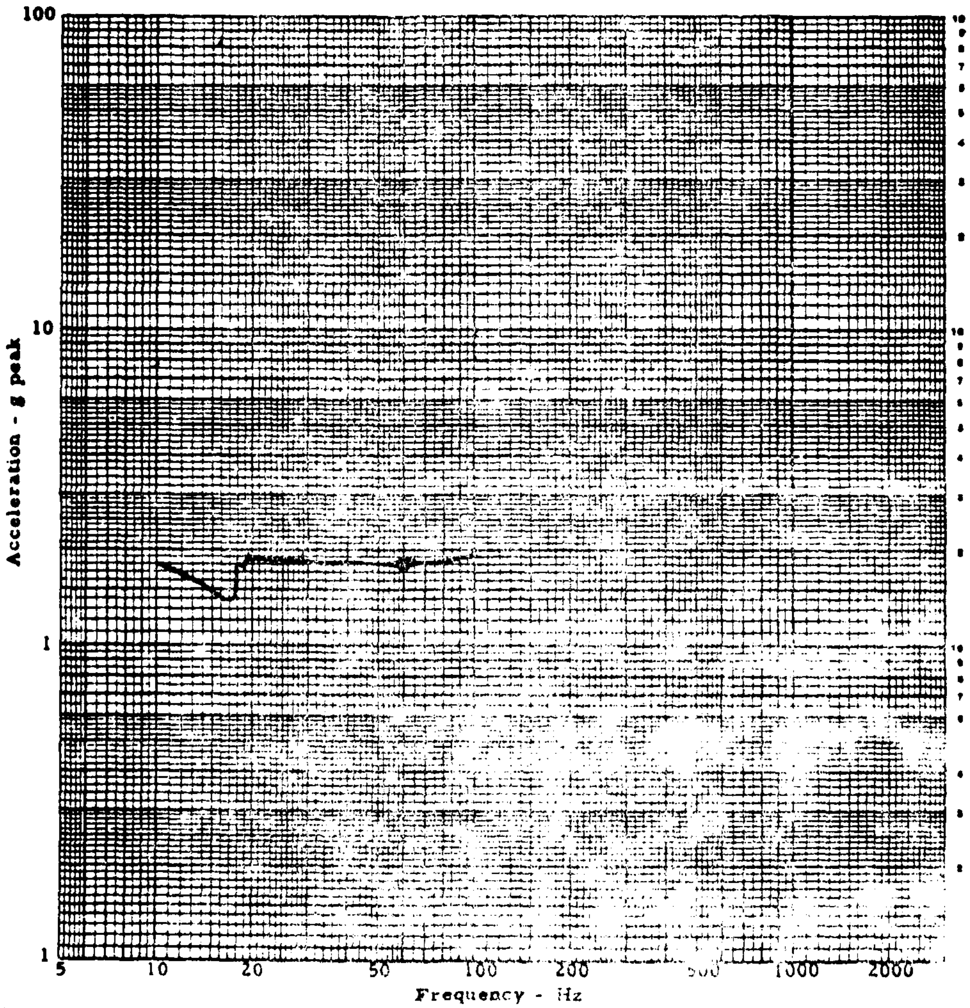
Bendix
Aerospace Systems Operations

TR FIGURE 9

VIBRATION LEVELS

Test Item: WRC ENGINE 5 [illegible] WR-400
Test Date: 1-31-80
Serial Number: 828
Input Axis: VERTICAL - SINE
Response Axis: TRI-AXIAL ACCEL.



440-8 A

SEQ. 5

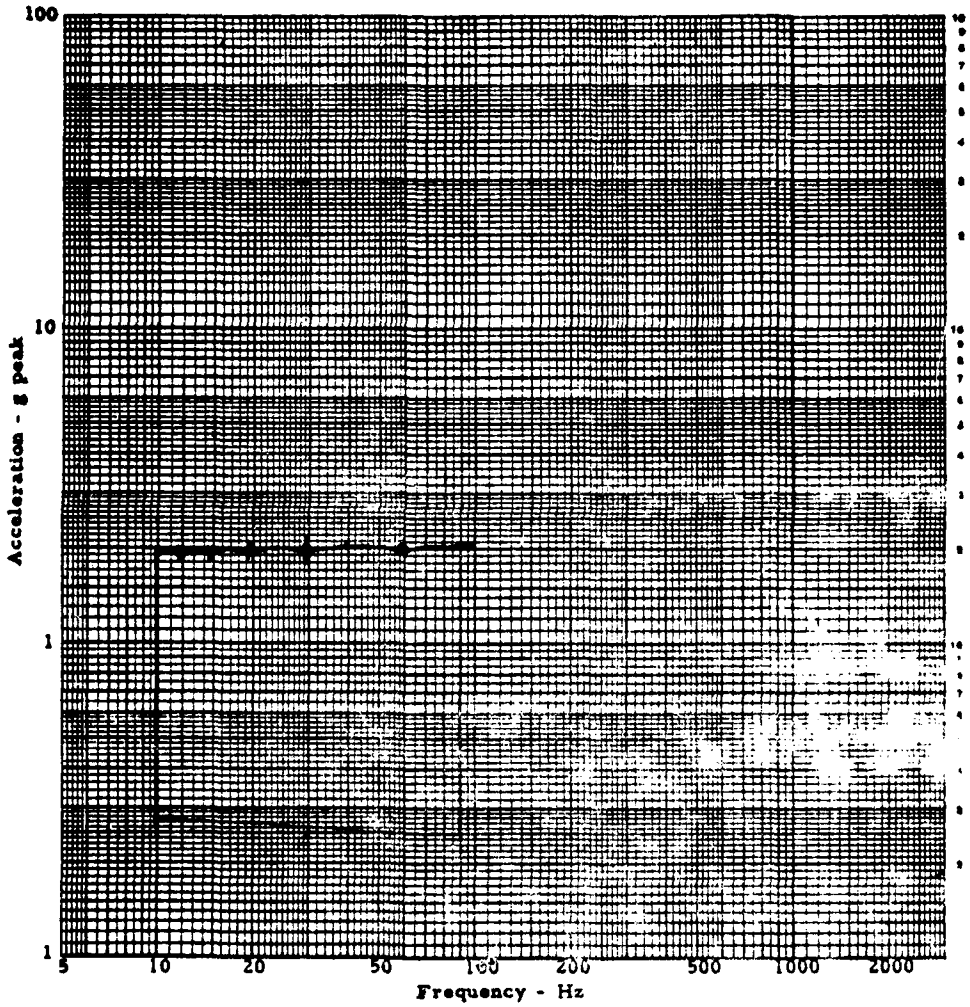
Bendix
Aerospace Systems Operations

TR
FIGURE 10

VIBRATION LEVELS - INPUT

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 228
Input Axis: VERTICAL - SINE
~~Response Axis:~~



440-8 A

SER.6

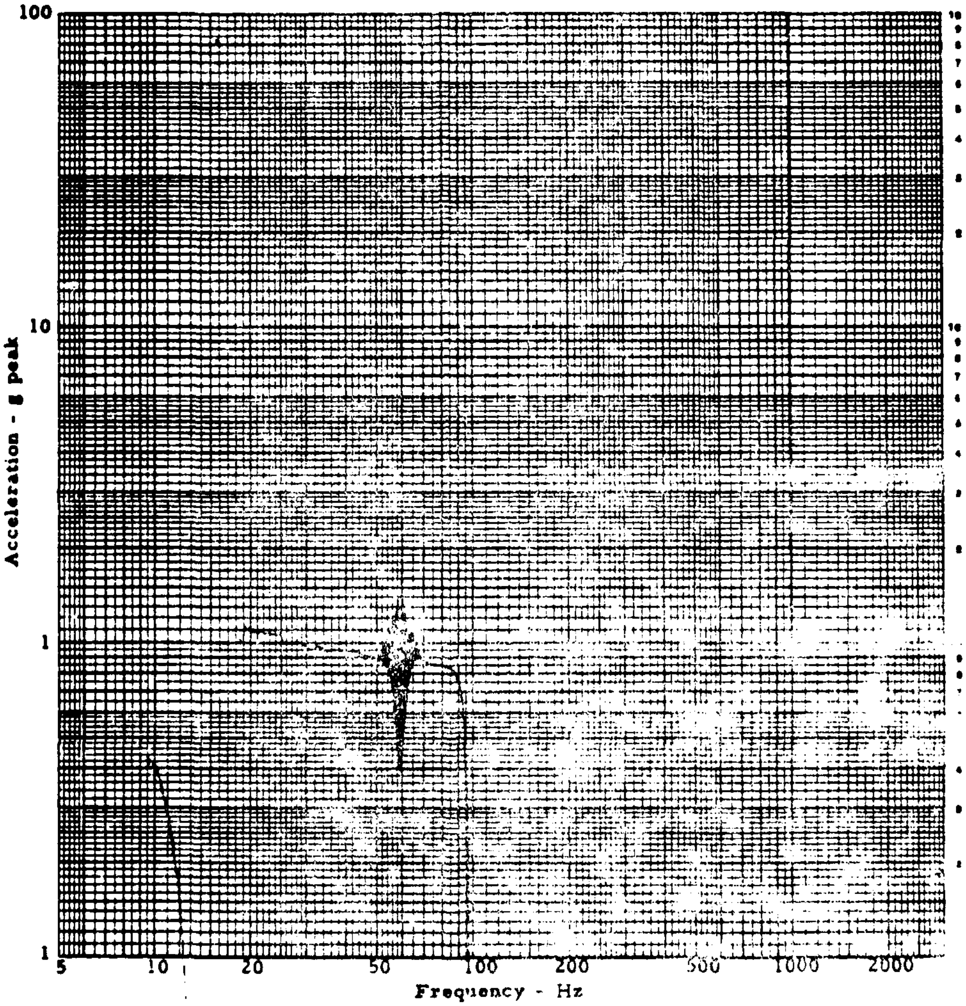
Bendix
Aerospace Systems Operations

TR FIGURE 11

VIBRATION LEVELS

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: VERTICAL - SINE
Response Axis: INLET HOUSING



440-8 A

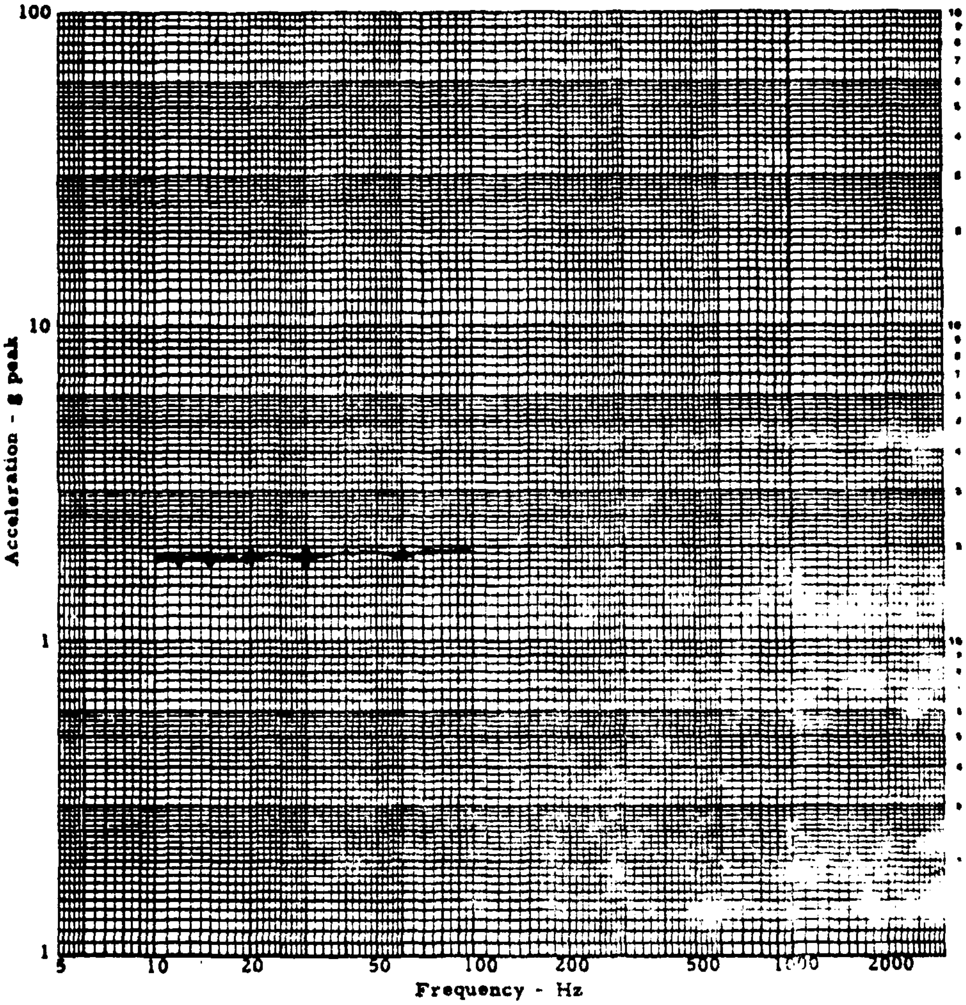
Bendix
Aerospace Systems Operations

TR
FIGURE 12

VIBRATION LEVELS -INPUT

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: VERT
~~Response Axis~~: CONTROL ACC.



440-8 A

SEQ. 9

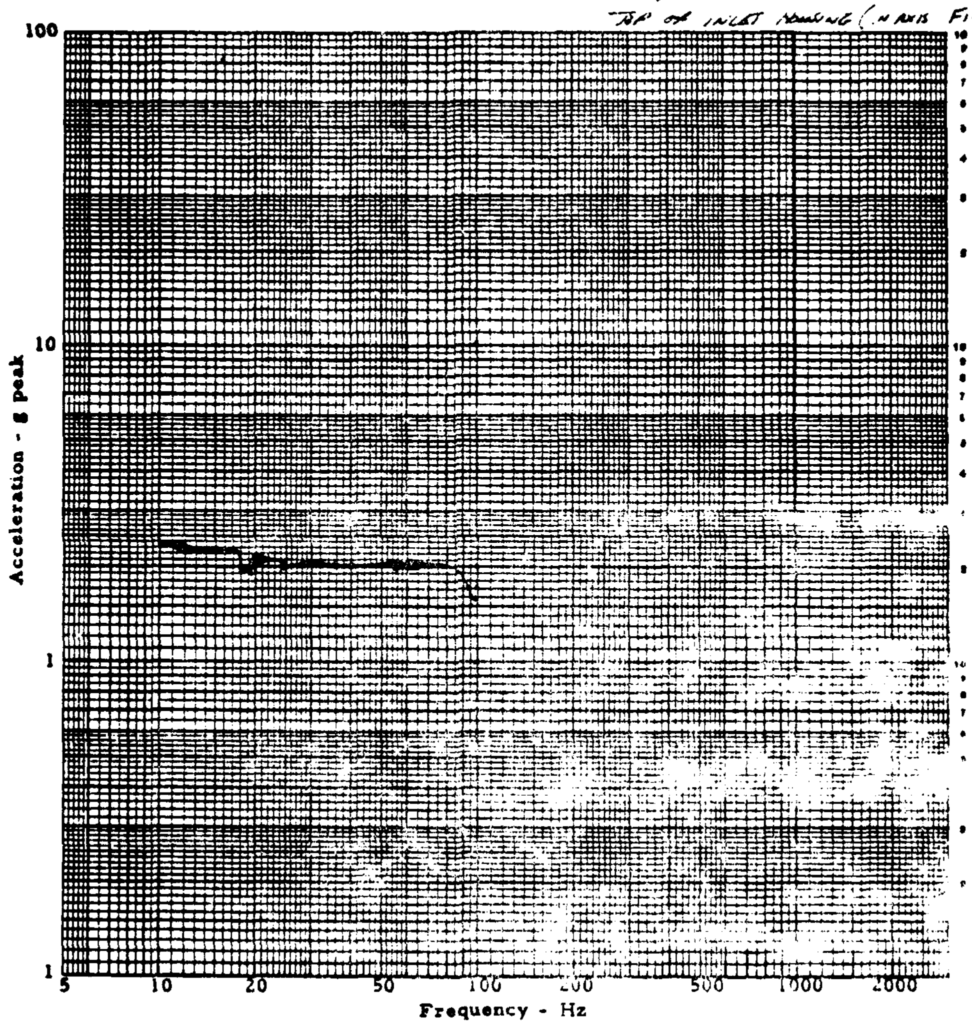
Bendix
Aerospace Systems Operations

TR
FIGURE 13

VIBRATION LEVELS

Test Item: WRC ENGINE F-107 WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: VERT - SINE
Response Axis:
TOP OF INLET HOUSING (N AXIS FILTERED



440-8 A

EQ 9

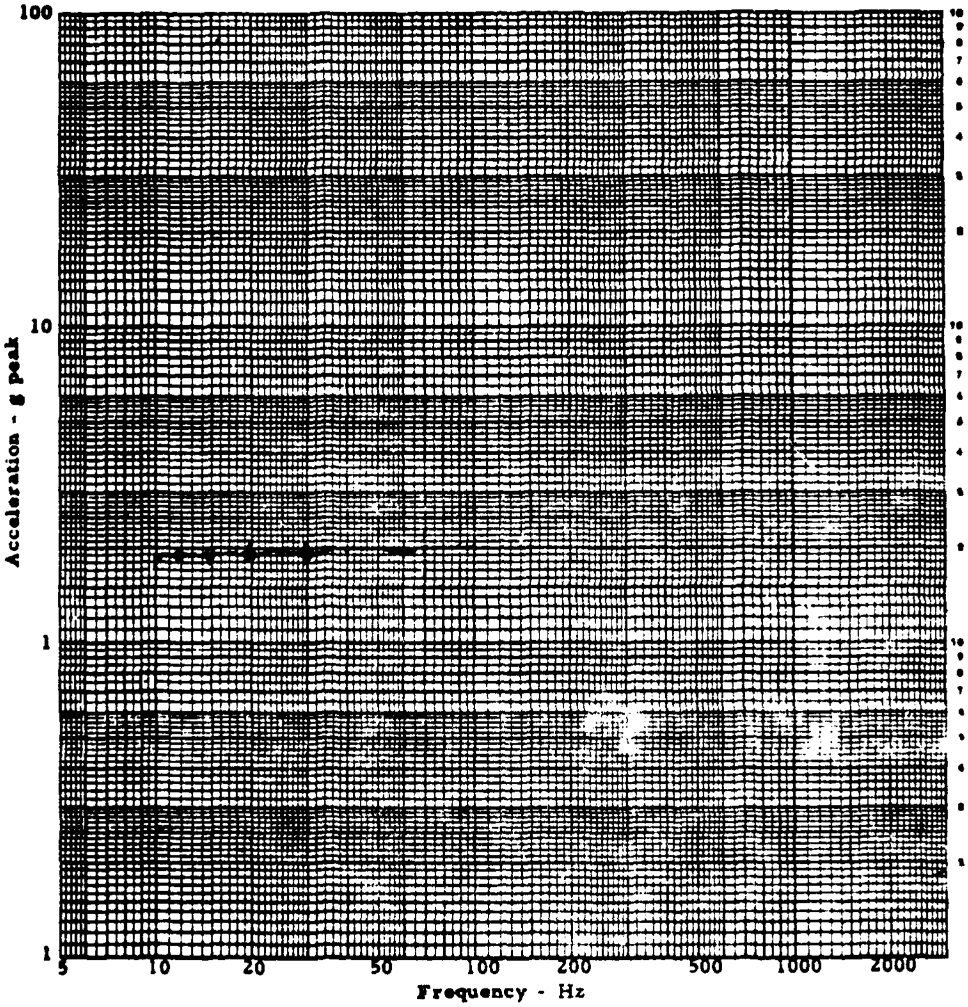
Bendix
Aerospace Systems Operations

TR
FIGURE 14

VIBRATION LEVELS - INPUT

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: VERT.
~~Response Axis:~~ CONTROL. ACC.



440-8 A

SEQ. 10

Bendix
Aerospace Systems Operations

TR FIGURE 15

VIBRATION LEVELS

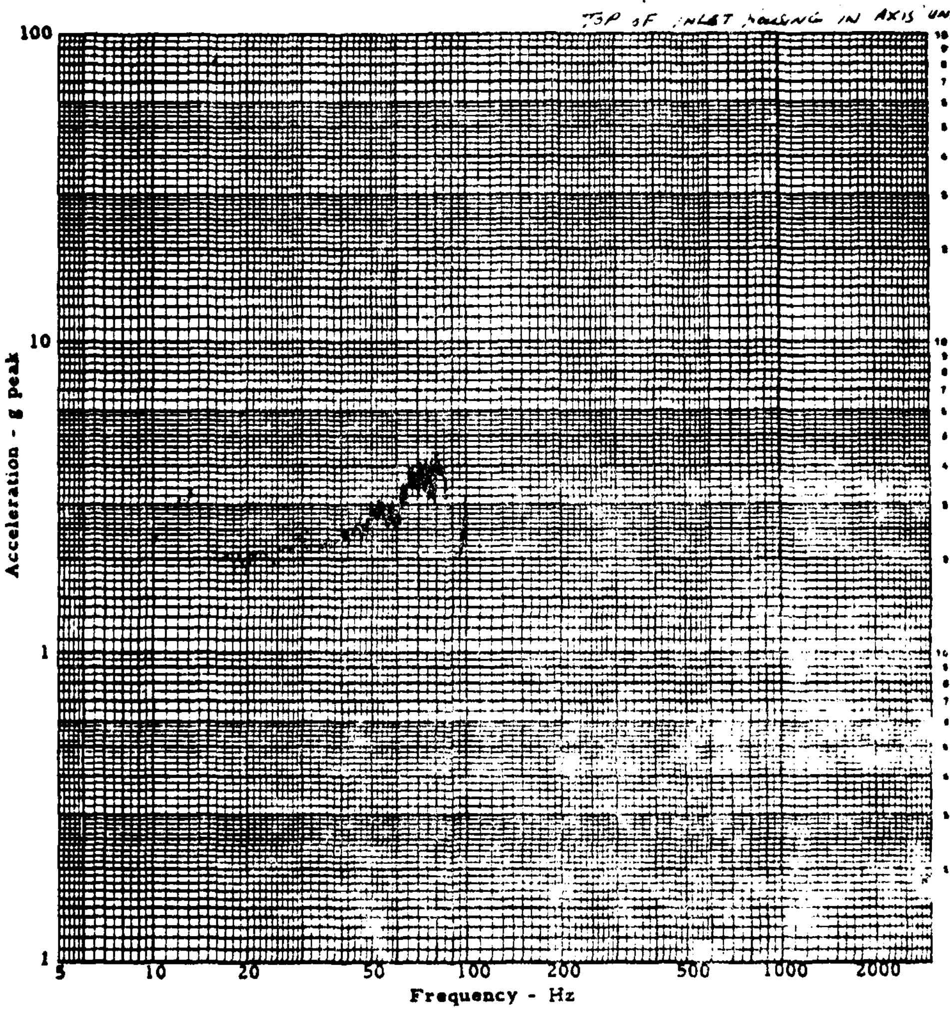
Test Item: NRC ENGINE F107-WR-400

Test Date: 1-5-80

Serial Number: 828

Input Axis: VERT - SINE

Response Axis: TOP OF INLET HOUSING IN AXIS UNFILTERED



440-8 A

SEQ. 10

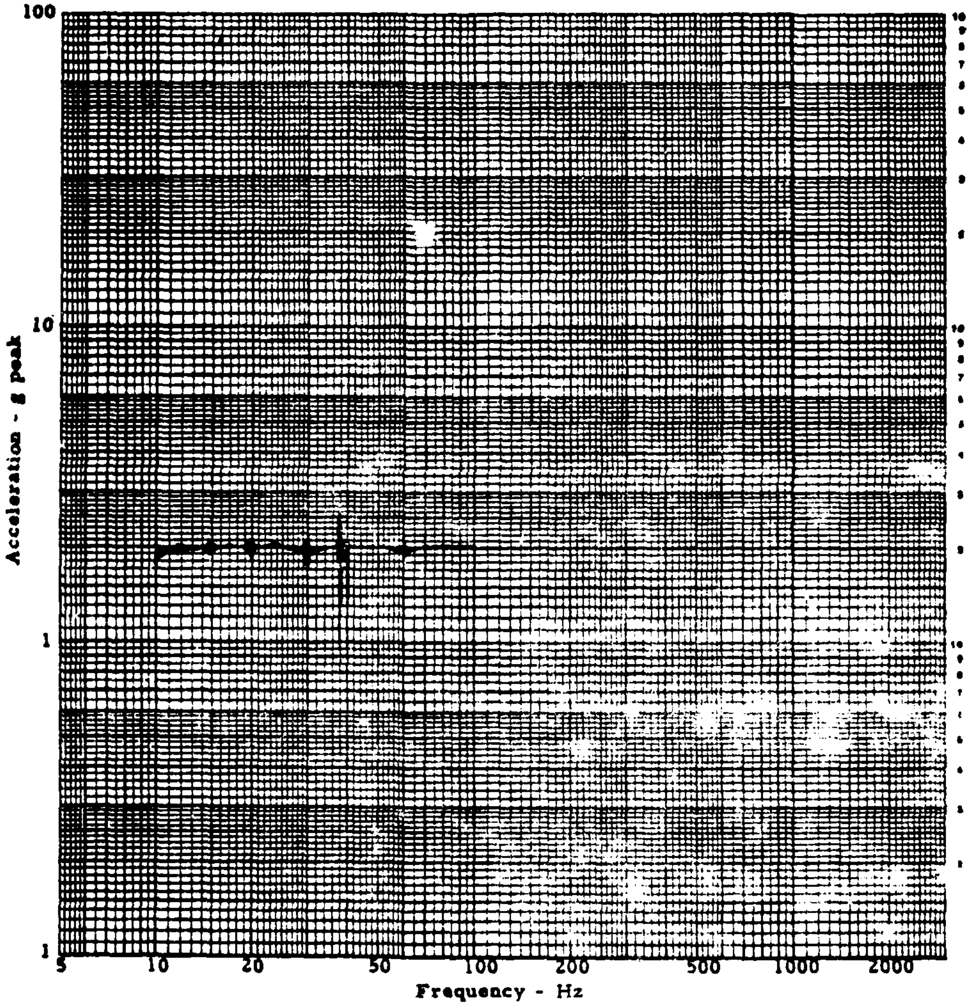
Bendix
Aerospace Systems Operations

TR
FIGURE 16

VIBRATION LEVELS - INPUT

Test Item: NRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: LATERAL
~~Response Axis:~~ CONTROL ACC.



440-8 A

SEQ. 13

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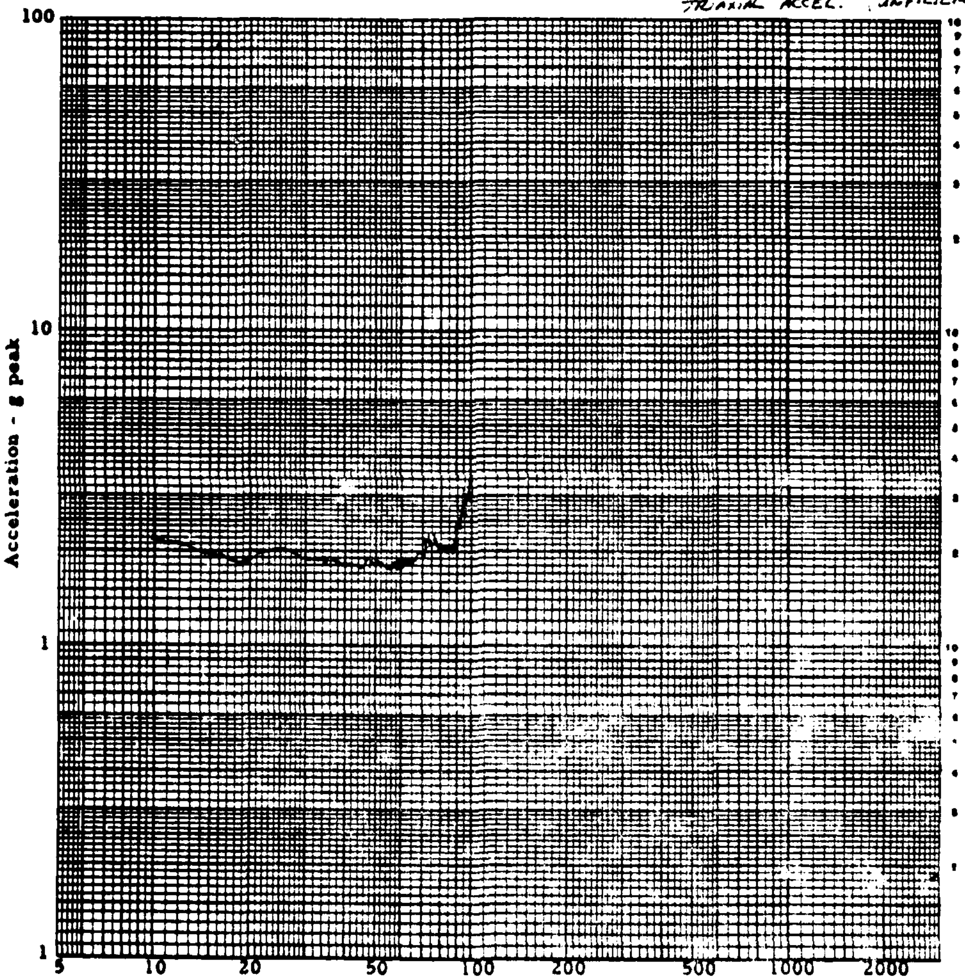
Bendix
Aerospace Systems Operations

TR
FIGURE 17

VIBRATION LEVELS

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: LATERAL
Response Axis: TRIAXIAL ACCEL. (UNFILTERED)



440-8 A

SEQ. 13

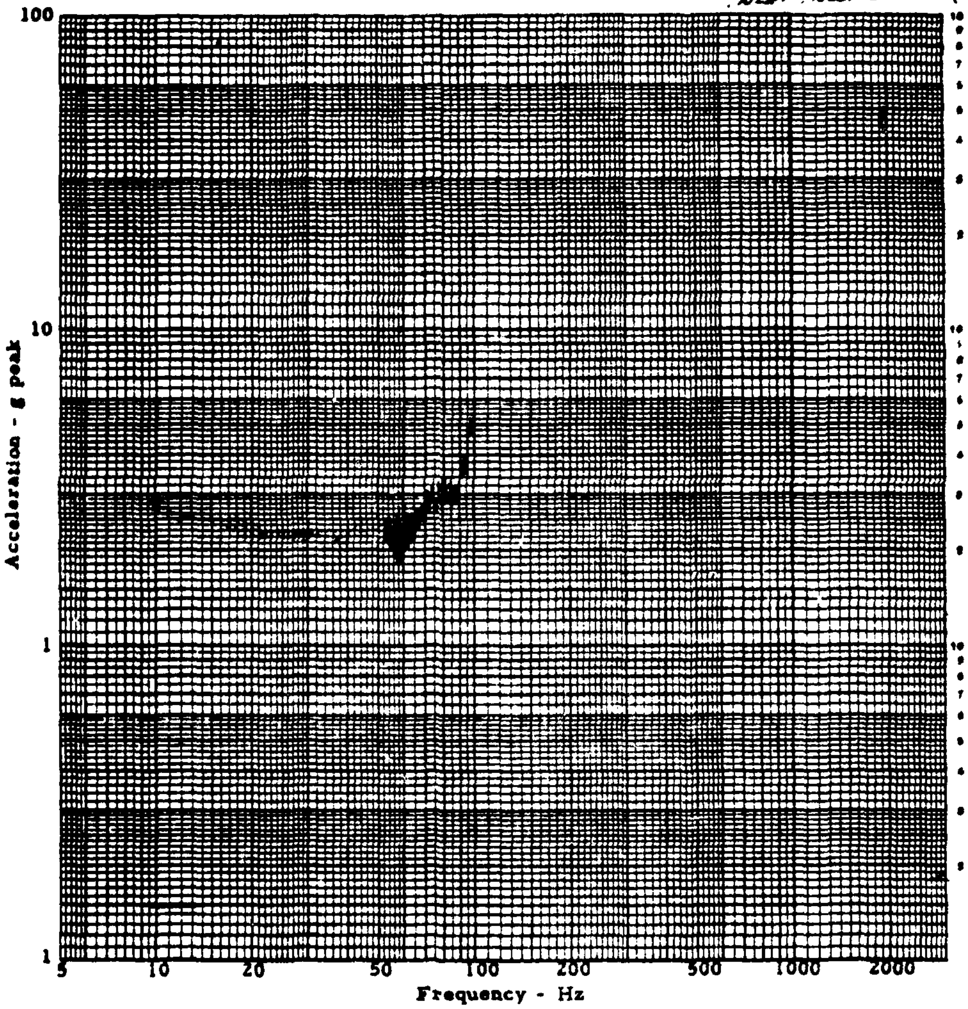
Bendix
Aerospace Systems Operations

TR
FIGURE 18

VIBRATION LEVELS

Test Item: WRC ENGINE F-107-WR-400
Test Date: 1-5-80

Serial Number: 828
Input Axis: LATERAL
Response Axis: INLET HOUSING ACCEL (UNPADDED



440-8 A

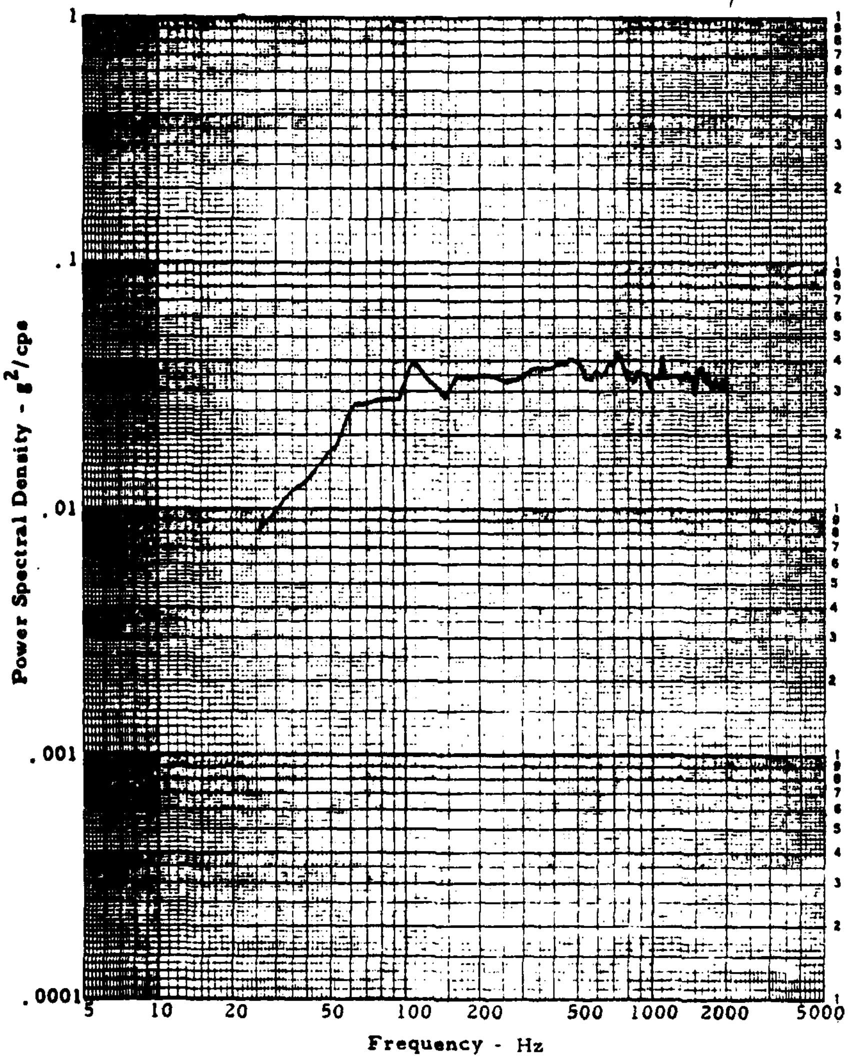
SEQ. 13

SYSTEMS TEST DEPARTMENT

TR
Figure 19

RANDOM VIBRATION SPECTRUM

Test: Qual Vib.
Test Item: WRC F107-WR-400
Test Date: 1-5-80
SN: 828
Axis: Y (LATERAL)



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Seq. 15
[illegible]

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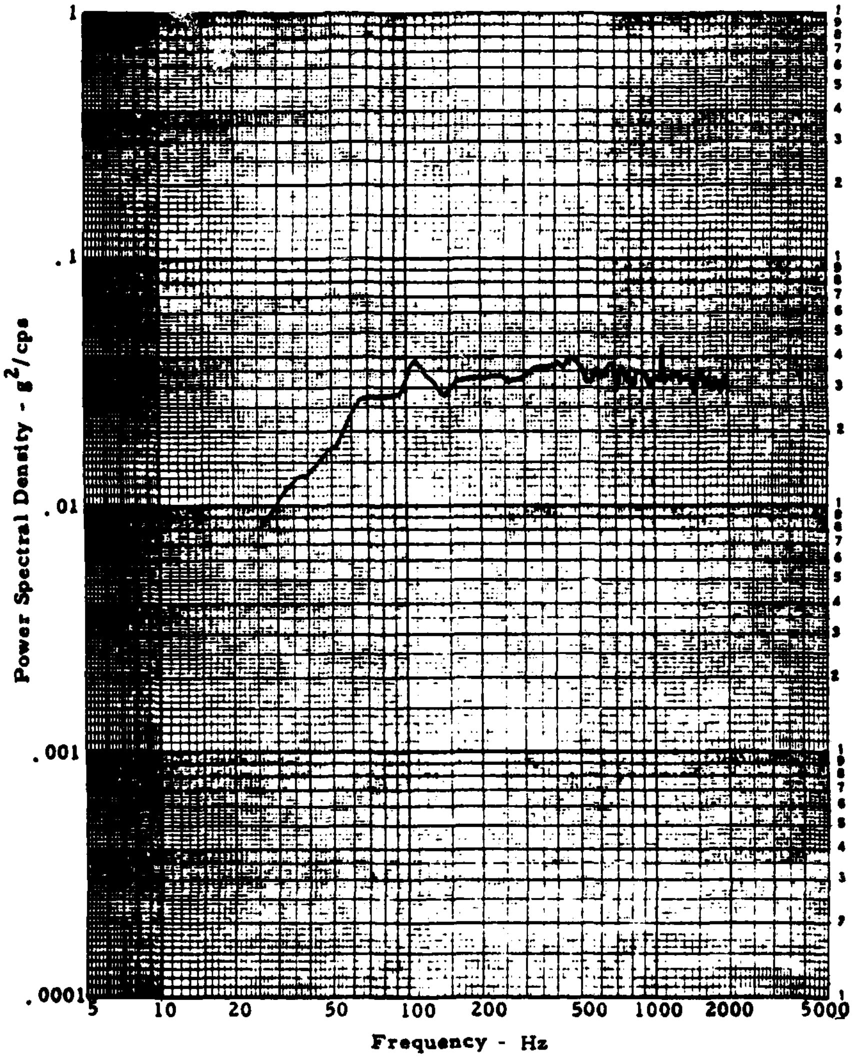
Systems Test Department

TR
Figure 20

RANDOM VIBRATION SPECTRUM

Test: Qual Vib.
Test Item: WR Eng. F107-WR-400
Test Date: 1-5-80
SN: 828
Axis: Y (Lateral)



Sep. 15
END

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AD-A102 257 WILLIAMS RESEARCH CORP WALLED LAKE MI F/G 21/5
CRUISE MISSILE ENGINE PROGRAM CONTRACT DATA REQUIREMENTS LIST S--ETC(U)
JUN 81 L TOOT N00019-78-C-0206
UNCLASSIFIED WRC-79-106-39 NL

3 OF 3
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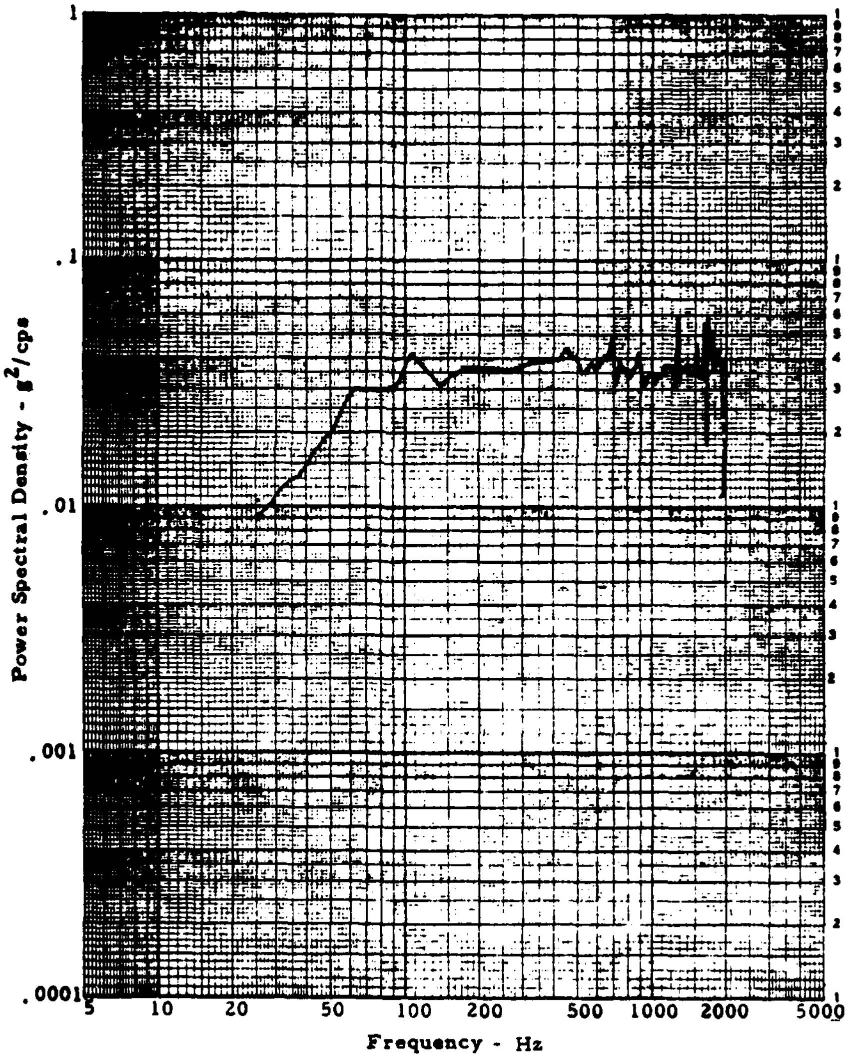
Aerospace Systems Division
SYSTEMS TEST DEPARTMENT

TR
Figure 21

RANDOM VIBRATION SPECTRUM

Test: QUAL.
Test Item: WRC ENGINE F107-WR-400
SN: 828
Test Date: 1-7-80
Axis: AXIAL (x)



440-13A

SEQ. 16
START

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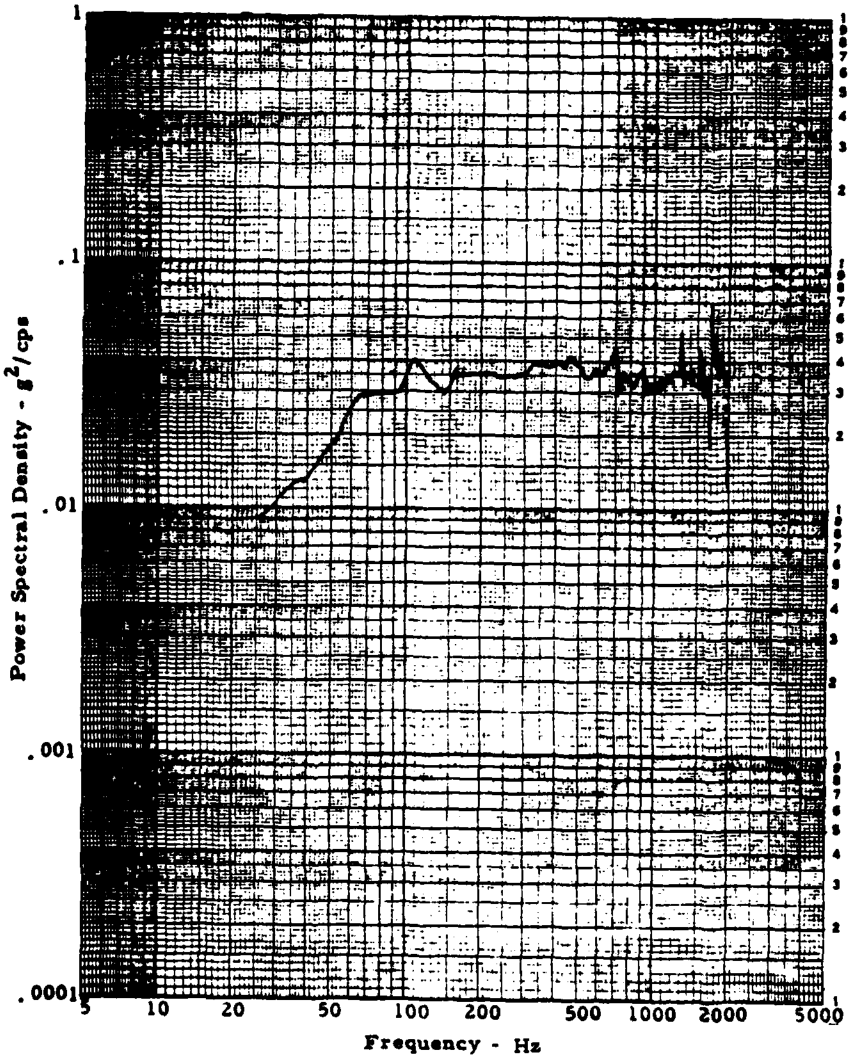
Report No. 79-106-39

SYSTEMS TEST DEPARTMENT

TR
Figure 22

RANDOM VIBRATION SPECTRUM

Test: Qual.
Test Item: WRC Engine F107-WR-400 SN: 828
Test Date: 1-7-80 Axis: Axial (x)



440-13A

Seq. 16
END.

SECTION III

A chronicle of events and the test curves obtained during the second vibration test series, conducted on 14 January 1980.

Williams Research Corporation

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Bendix Aerospace Systems Division

LR ______
Page 3

TEST SEQUENCE

Test Item: WRC ENGINE — PN: F107-WR-400
Test: QUAL. — SN: 828 — Date: 1-14-80
Technician: ANDERSON — Test Engineer: [illegible]

Seq No.	Time of Day	Axis	Test Mode No.	Test Time	Remarks
1	1259	Vert	1	5m	10-100 Hz @ 2g PLOTTED INLET ACC.
2	1303	"	1	5m	100-10 Hz @ 2g PLOTTED TRIAX (Y)
3	1345	"	2	30m	Dwell @ 77 Hz - INLET PEAKED @ ~4.4 g P.
4	1420	"	2	30m	Dwell @ 91 Hz - INLET PEAKED @ ~4.1 g PK
5	1452	"	2	30m	" " 100 Hz - " " " 6.2 g PK
6	1540	"	3	30m	7.4 grms - INLET 8.4 grms
					1-15-80
7	0913	Axial	3		START RANDOM 7.6 grms
8	1034	"	3	30m	END RANDOM "
9	1357	Vert	3	30m	7.8 grms RANDOM
10	1418	"	1	5m	10-100 Hz - PLOTTED INLET
11	1424	"	1	5m	100-10 Hz " TRIAX
12	1458	"	2	30m	Dwell @ 13 Hz INLET PEAKED @ 4.2 g PK
13	1529	"	2	30m	" " 83 Hz " " @ 4.5 g PK
14	1600	"	2	30m	" " 100 Hz " " @ 5.5 g PK

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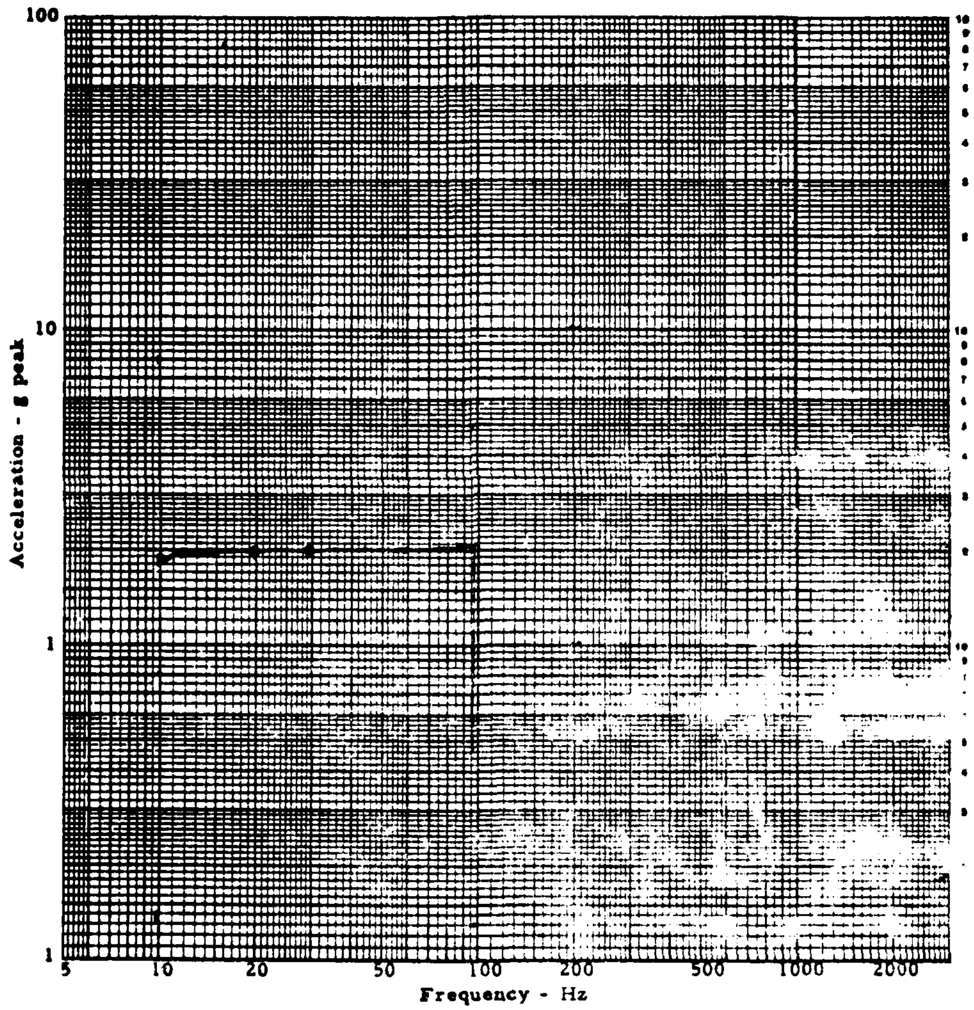
Bendix
Aerospace Systems Operations

TR FIGURE 1

VIBRATION LEVELS - INPUT

Test Item: WRC ENGINE F107-WR-400
Test Date: 1-14-80

Serial Number: 828
Input Axis: LATERAL (Y)
~~Response Axis:~~ CONTROL



440-8 A

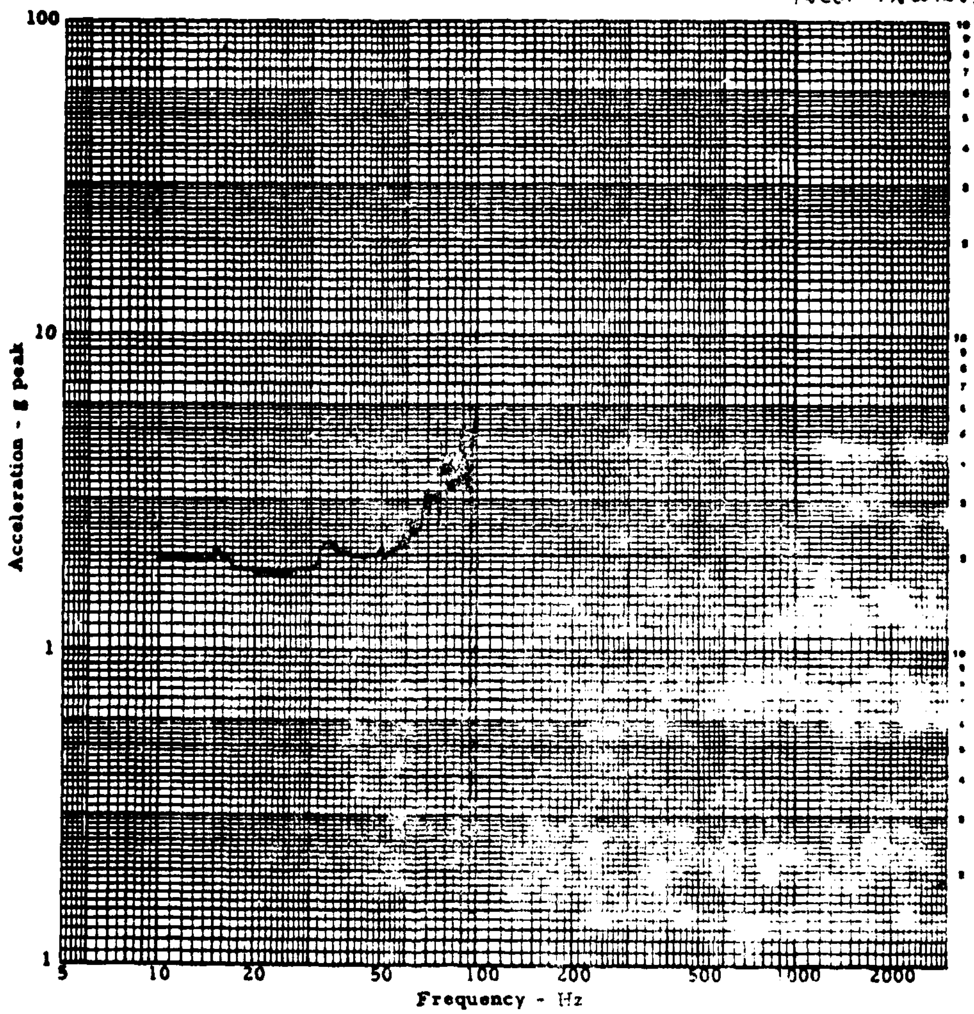
Bendix
Aerospace Systems Operations

TR
FIGURE 2

VIBRATION LEVELS

Test Item: WRC ENGINE F107-WR-400
Test Date: 1-14-80

Serial Number: 828
Input Axis: LATERAL (Y)
Response Axis: INLET HOUSING



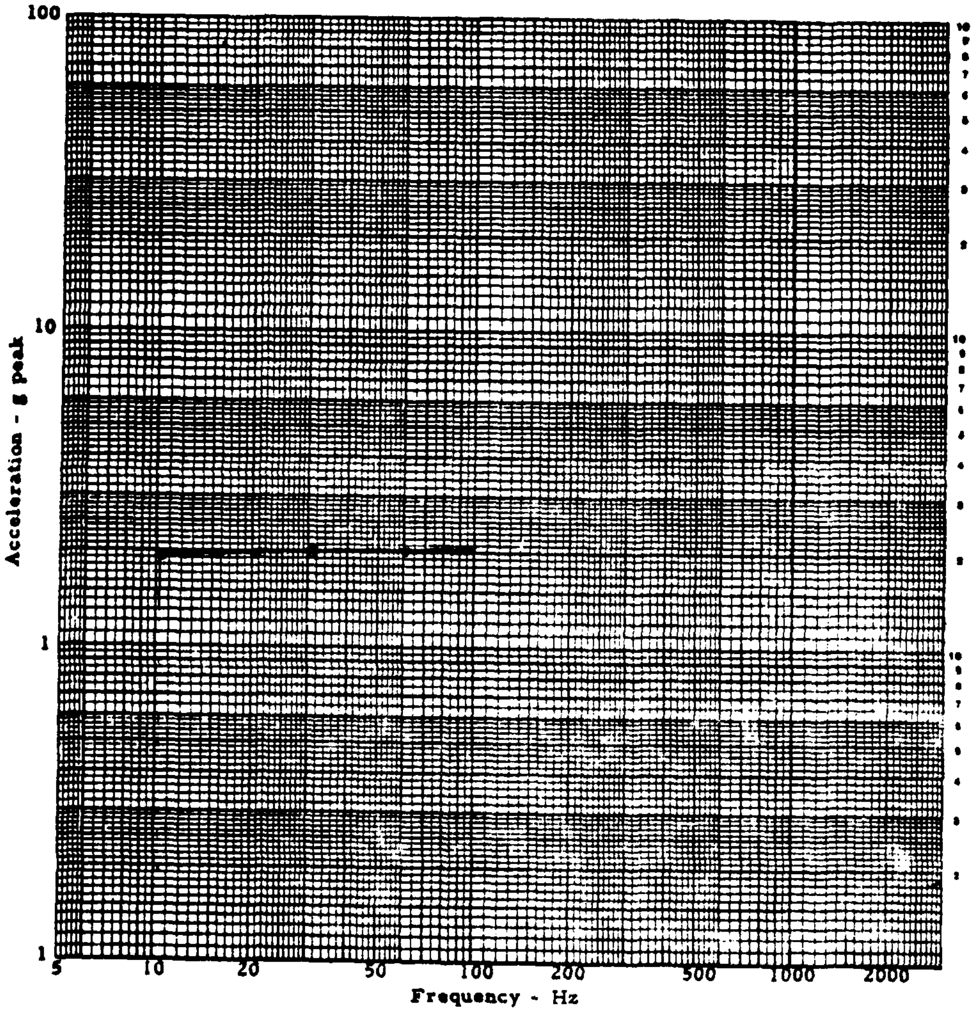
440-8 A

Bendix
Aerospace Systems Operations

TR FIGURE 3

VIBRATION LEVELS - INPUT

Test Item: WRC ENGINE F107-WR-400 Serial Number: 828
Test Date: 1-14-80 Input Axis: LATERAL (Y)
~~Response Axis:~~ CONTROL



440-8 A

SEQ. 2

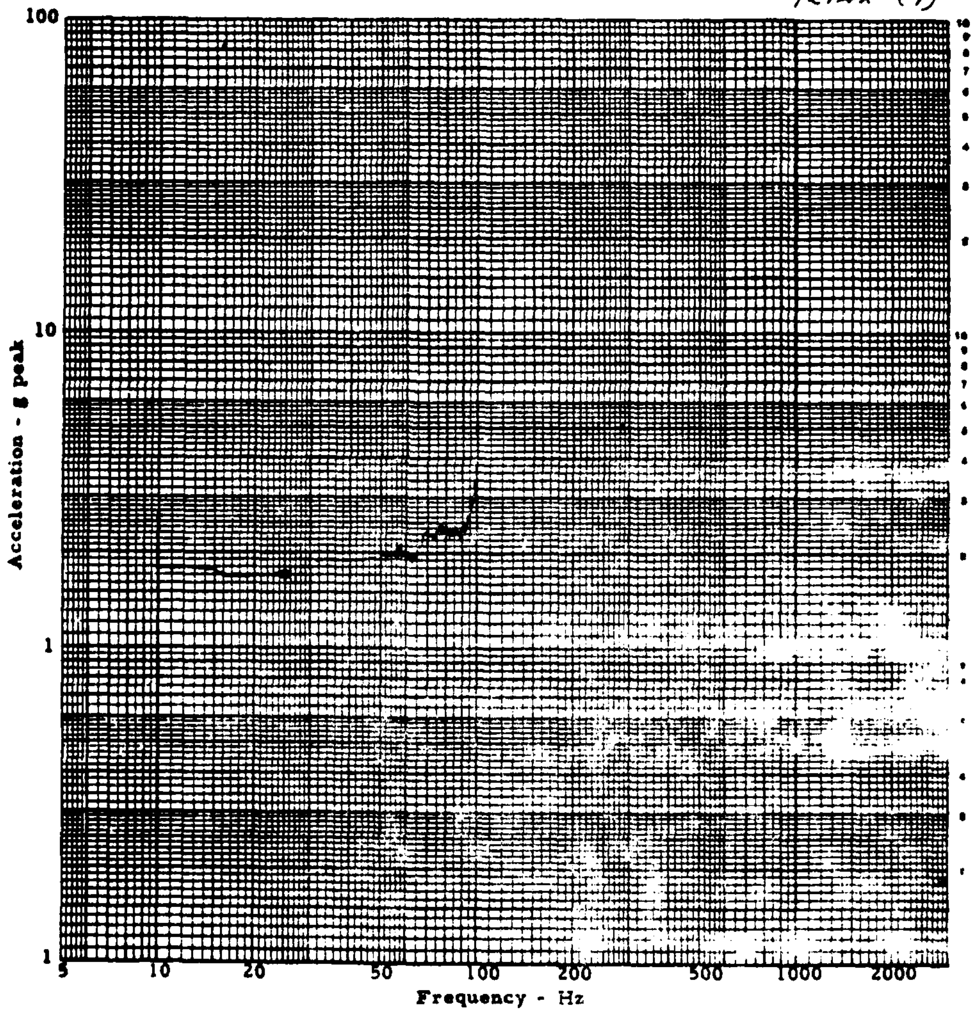
Bendix
Aerospace Systems Operations

TR
FIGURE 4

VIBRATION LEVELS

Test Item: WRC ENGINE F107-WR-400
Test Date: 1-14-80

Serial Number: 828
Input Axis: LATERAL (Y)
Response Axis: TRIAX (Y)



440-8 A

SEQ -

Williams Research Corporation

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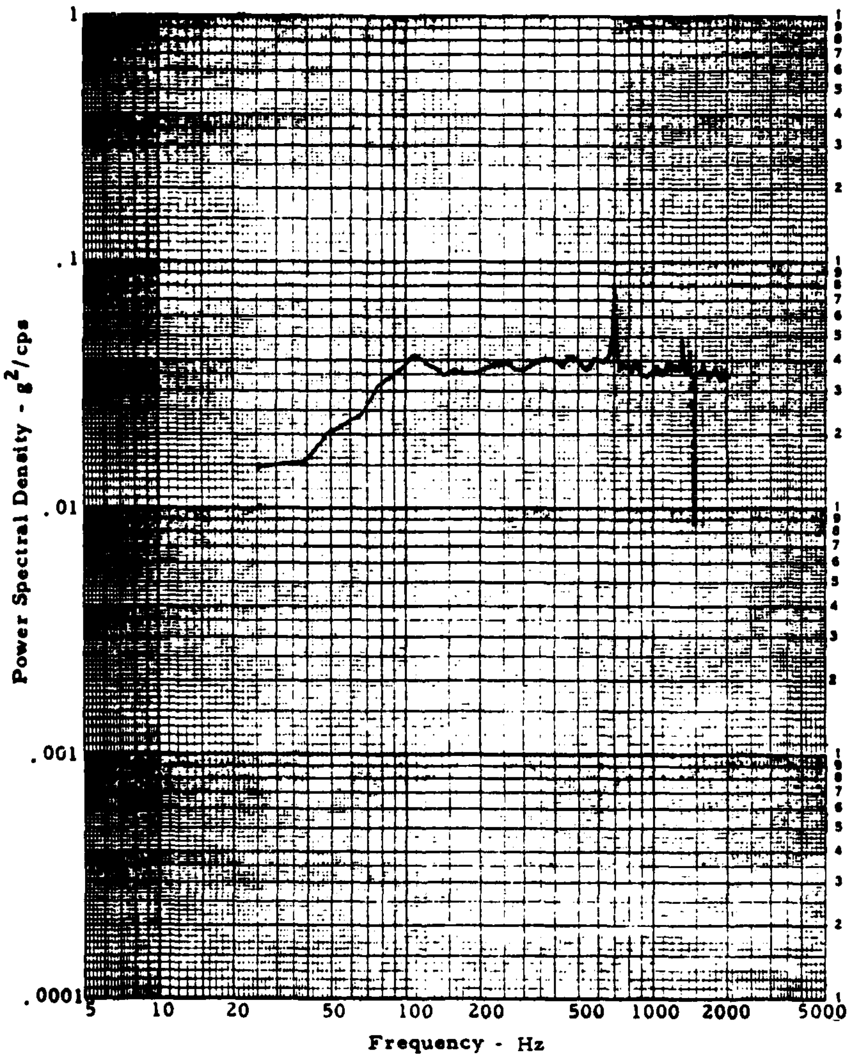
SYSTEMS TEST DEPARTMENT

TR
Figure 5

RANDOM VIBRATION SPECTRUM

Test: QUAL.
Test Item: WRC ENGINE F107-WR-400 SN: 828
Test Date: 1-14-80 Axis: LATERAL (Y)



SEQ. 6
START

440-13A

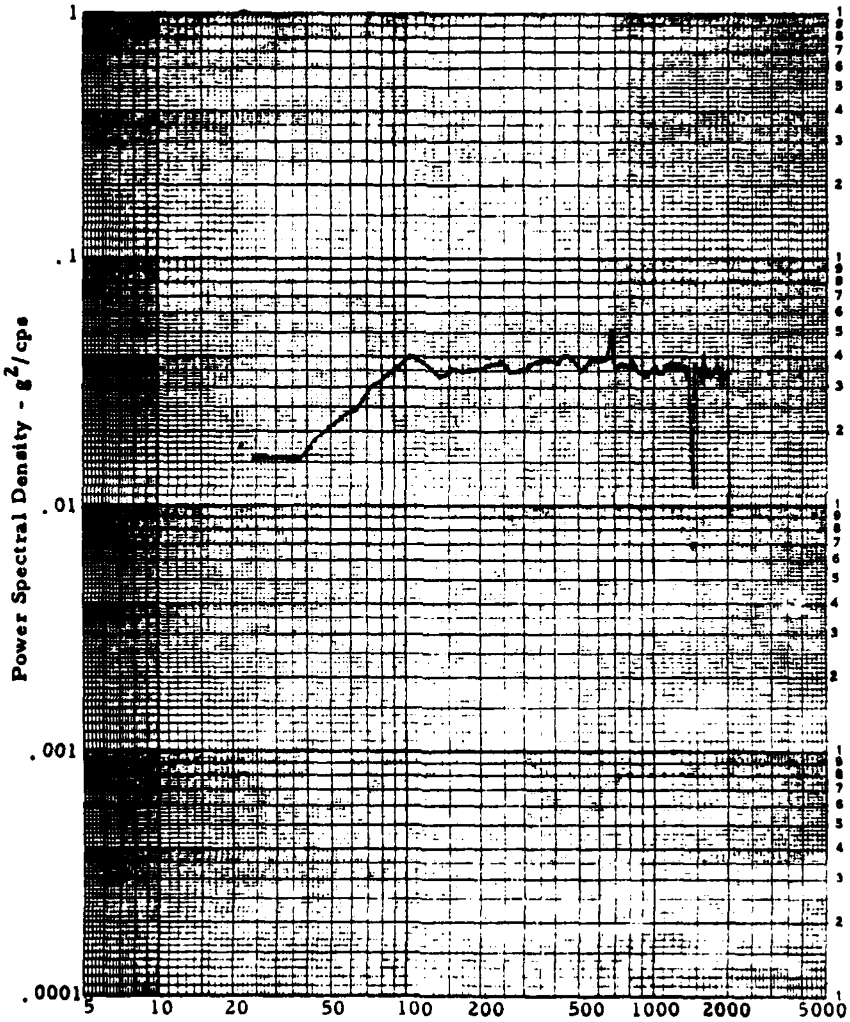
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 6

RANDOM VIBRATION SPECTRUM

Test: QUAC.
Test Item: WRC ENGINE F107-WR-400 SN: 828
Test Date: 1-14-80 Axis: LATERAL (Y)



440-13A

SEQ. 6
END

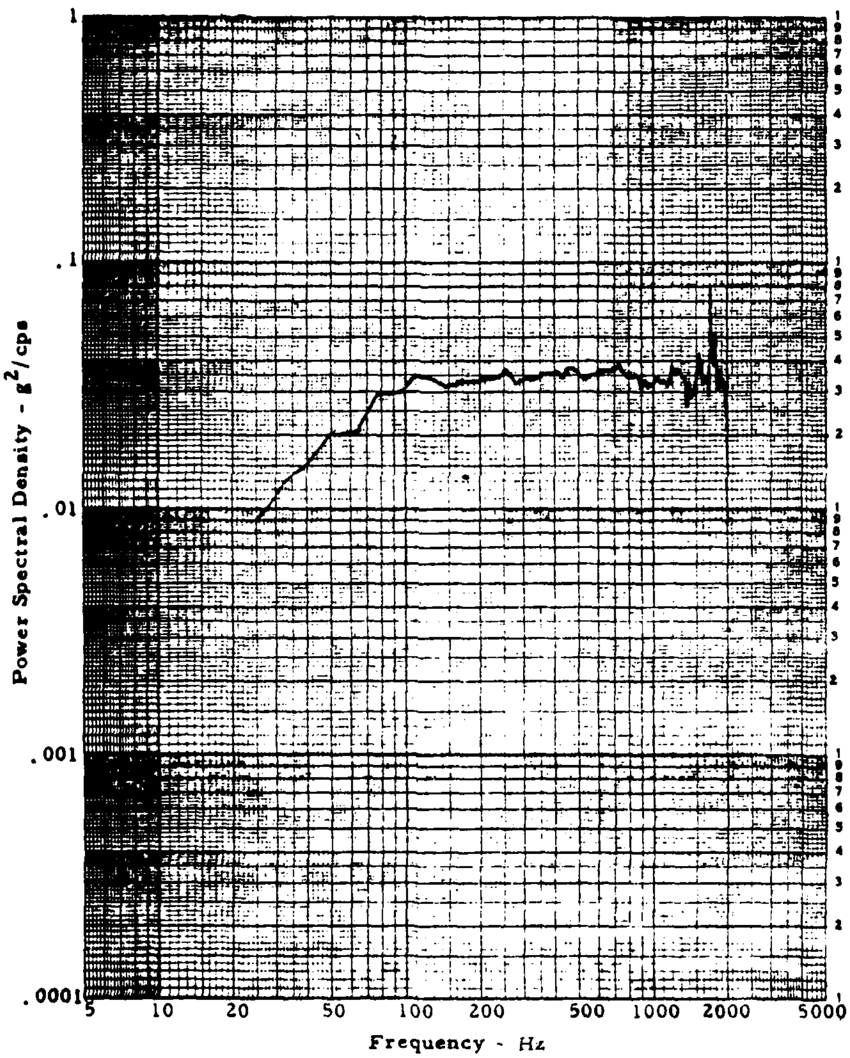
Bendix Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 7

RANDOM VIBRATION SPECTRUM

Test: QUAL.
Test Item: WRC ENGINE F(0)-WR-400 SN: 828
Test Date: 1-18-80 Axis: AXIAL (x)



440-13A

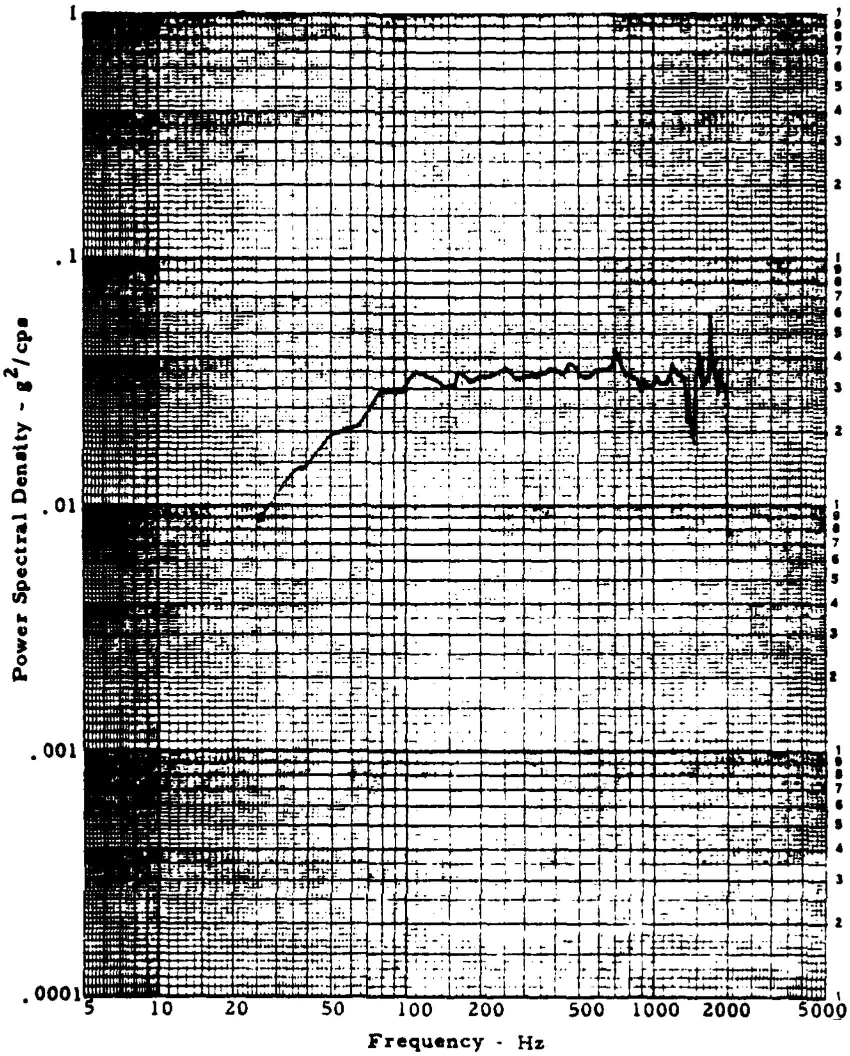
SEQ.7
START

SYSTEMS TEST DEPARTMENT

TR
Figure 8

RANDOM VIBRATION SPECTRUM

Test: QUAL
Test Item: WRC ENGINE F107-WR-400 SN: 828
Test Date: 1-15-80 Axis: AXIAL (X)



440-13A

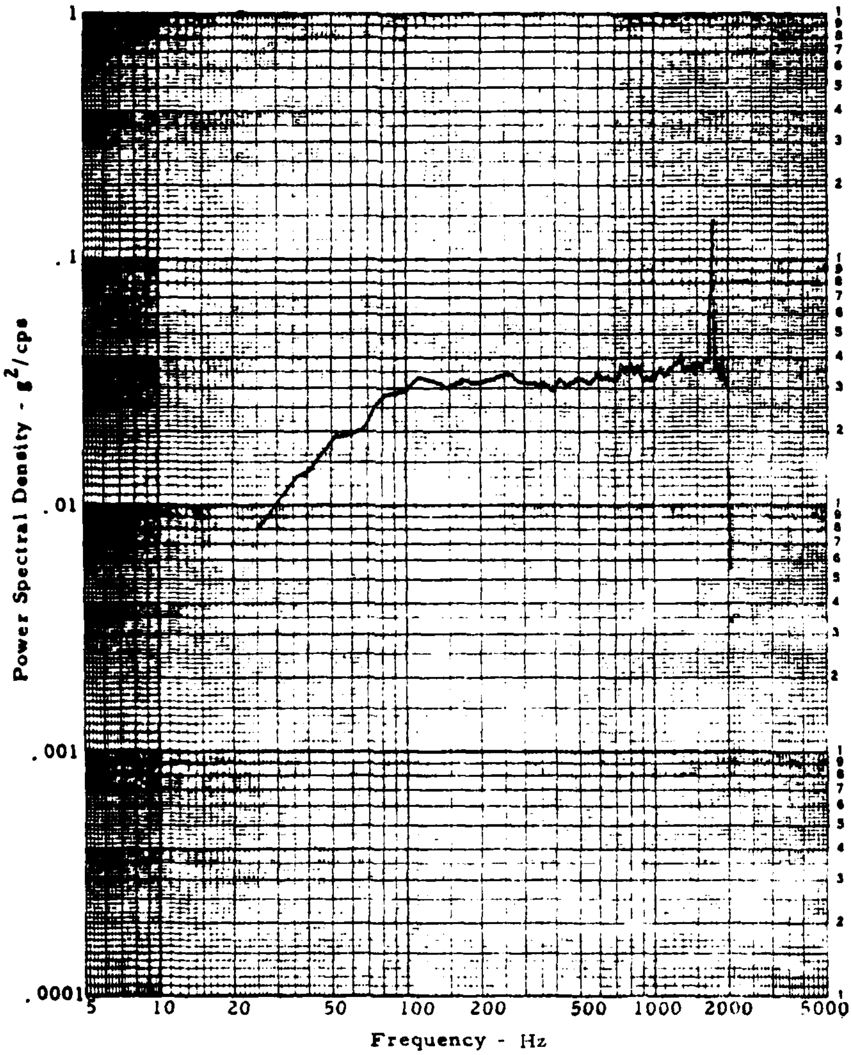
SEQ. 8
END

SYSTEMS TEST DEPARTMENT

TR
Figure 9

RANDOM VIBRATION SPECTRUM

Test: QUAC
Test Item: WRR ENGINE (F107-WR-400) SN: 828
Test Date: 1-15-80 Axis: VERTICAL (Z)



440-13A

SEQ 9
START

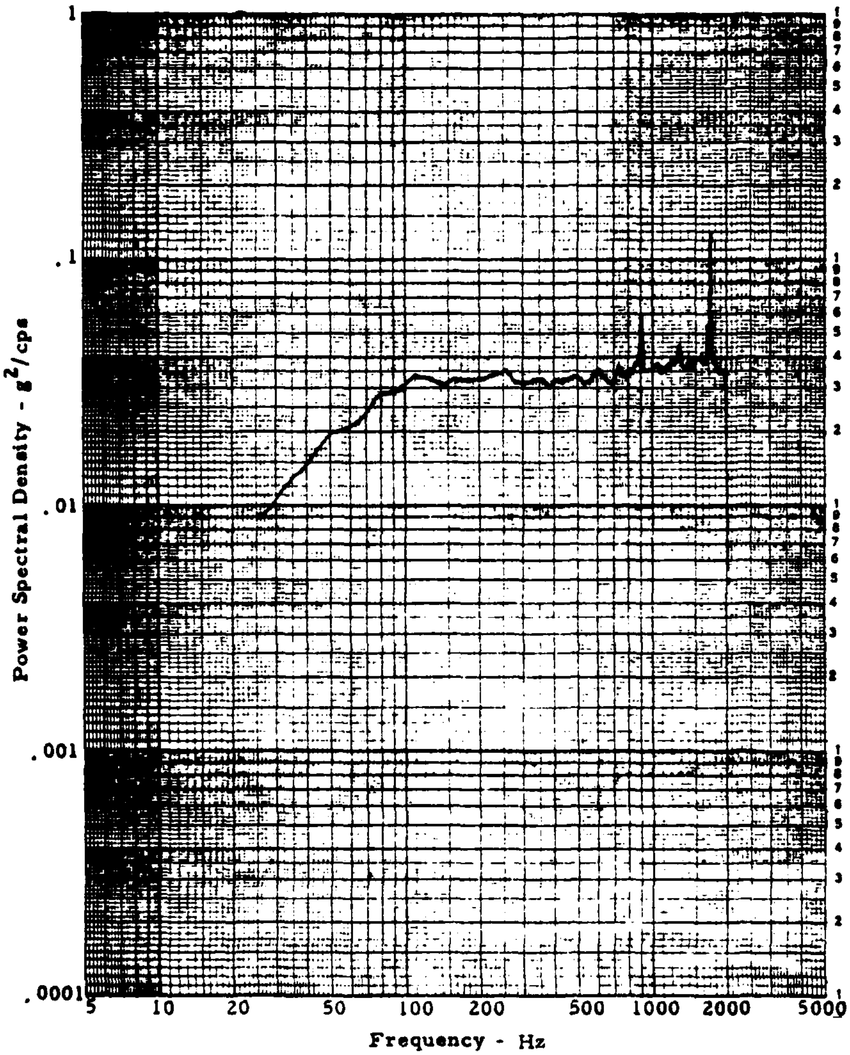
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 10

RANDOM VIBRATION SPECTRUM

Test: QUAL.
Test Item: WRC ENGINE F107-WR-400 SN: 828
Test Date: 1-15-80 Axis: VERTICAL (Z)



SEQ. 8
END

440-13A

Bendix

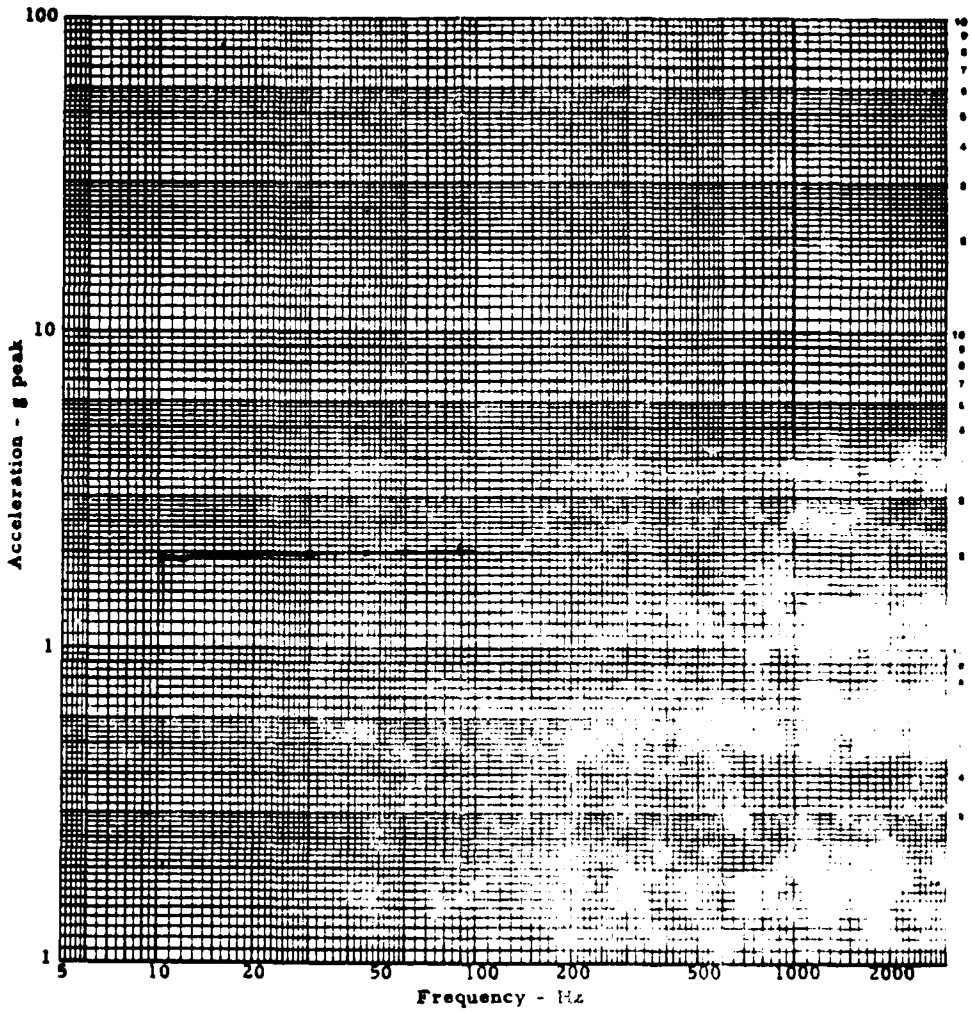
Aerospace Systems Operations

TR FIGURE 11

VIBRATION LEVELS – INPUT

Test Item: QUAL WRC ENGINE
Test Date: 1-15-80

Serial Number: 820
Input Axis: VERTICAL
~~Response Axis:~~ CONTROL



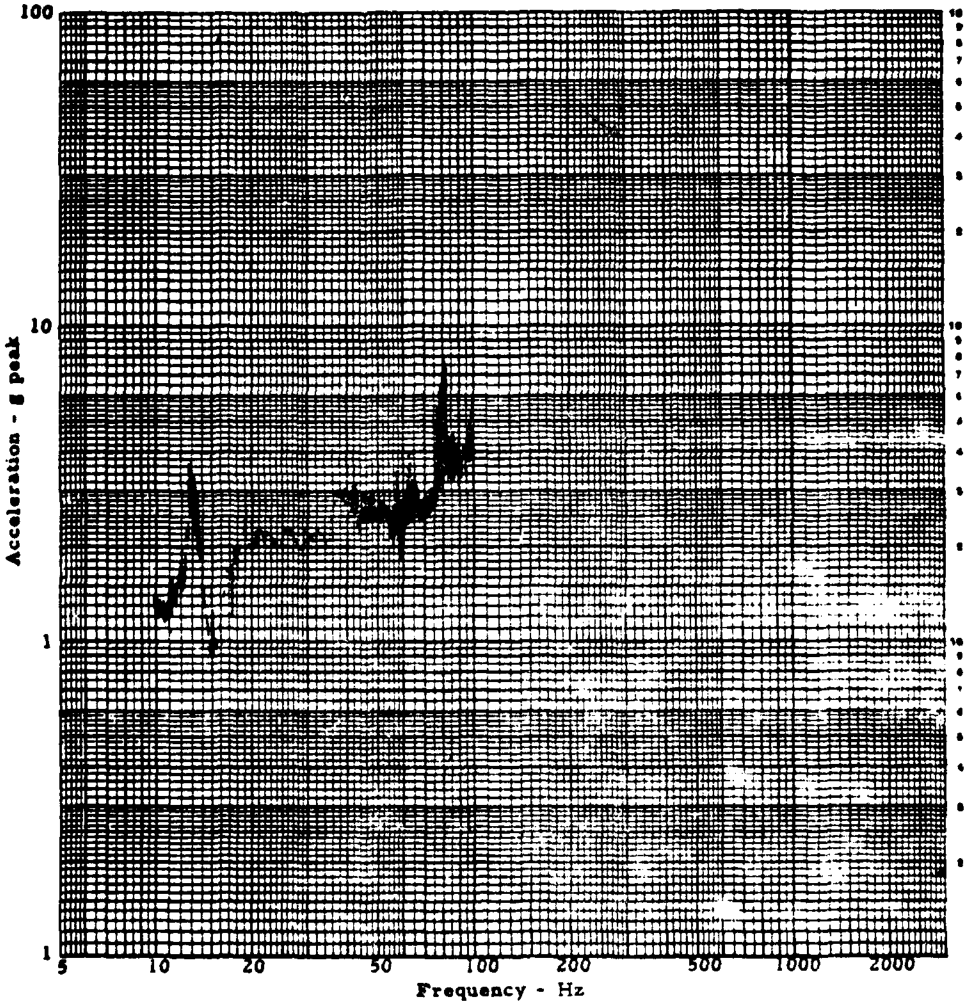
440-8 A

Bendix
Aerospace Systems Operations

TR FIGURE 12

VIBRATION LEVELS

Test Item: QUAL. WRC ENGINE F107-WR-400 Serial Number: 828
Test Date: 1-15-80 Input Axis: VERTICAL
Response Axis: INLET HOUSING



440-8 A

SEQ. 10

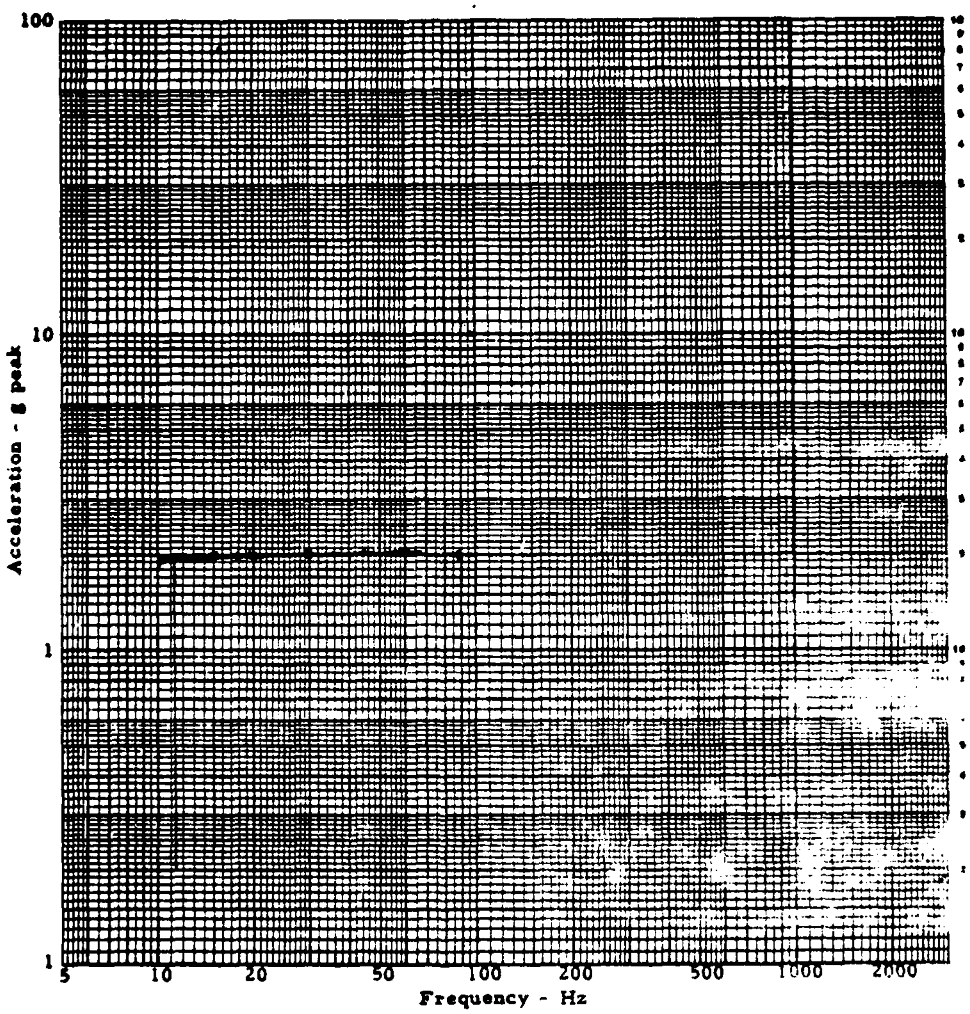
Bendix
Aerospace Systems Operations

TR FIGURE 13

VIBRATION LEVELS - INPUT

Test Item: QUAL. WRC ENGINE F107-WR-100
Test Date: 1-15-80

Serial Number: 828
Input Axis: VERTICAL
~~Response Axis:~~ CONTROL



440-8 A

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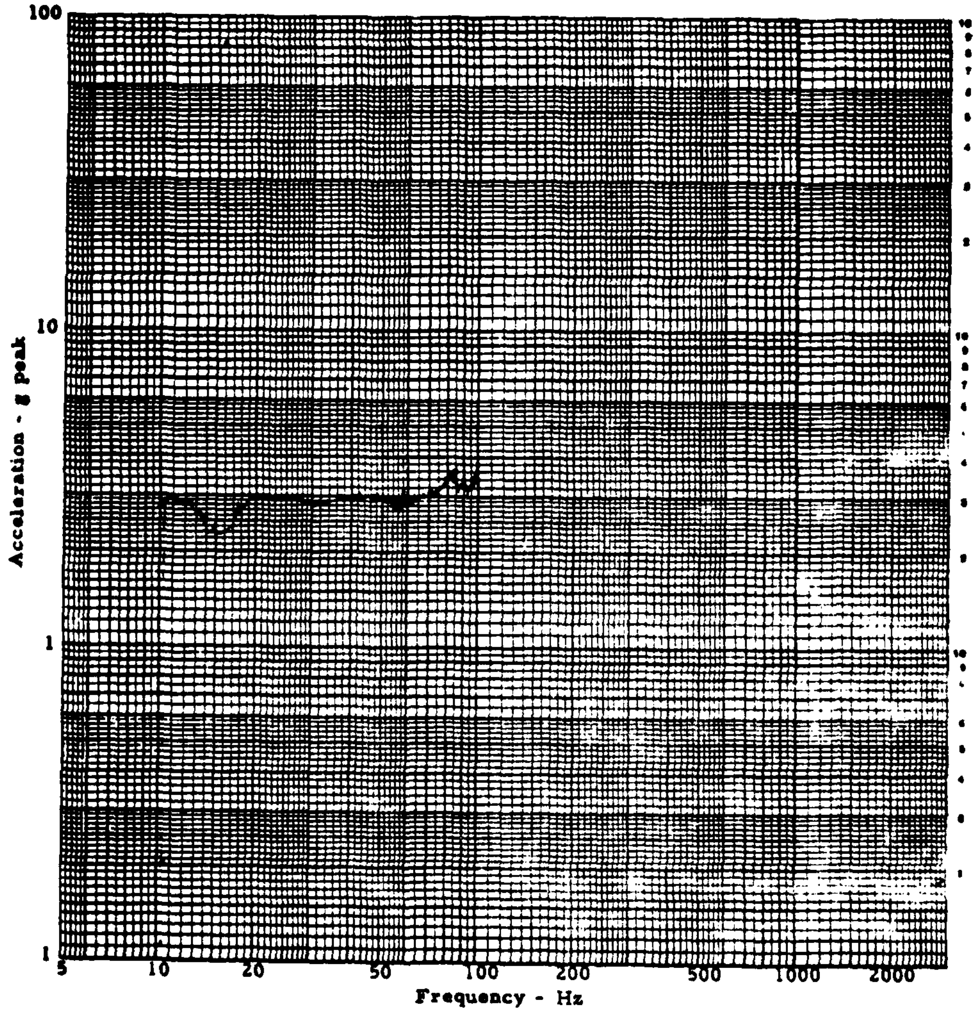
Bendix
Aerospace Systems Operations

TR FIGURE 14

VIBRATION LEVELS

Test Item: QUAL WRC ENGINE
Test Date: 1-15-80
Serial Number: 828
Input Axis: VERTICAL
Response Axis: TRIAX



440-8 A

SECTION IV

A chronicle of events and the test curves obtained during the conduction of F107-WR-400 specified environmental vibration tests on fuel control unit S/N 1443454.

Williams Research Corporation

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Bendix Aerospace Systems Division

QWA 12871
LR
Page 1

TEST SEQUENCE

Test Item WRC ENGINE F107-WR-400 JN
Test VIBRATION SN 704 Date 4-8-80
Technician [illegible] Test Engineer MONROE

Seq No.	Time of Day	Axis	Test Mode No.	Test Time	Remarks
1	1405	VERT		5 MIN	10-100 HZ @ 2.0g PLOTTING INLET HOUSING ACC.
2	1410	"		5 MIN	100-10 HZ @ 2.0g PLOTTING TRI-AXIAL ACC.
3	1420	"		30 MIN	DWELL @ 100 HZ 2.0g INPUT INLET: 4.5g TRI-AX: 4.3g
4	1450	"		30 min.	DWELL @ 16 HZ 2.0g INPUT INLET: 2.8g TRI-AX: 2.4g
5	1528	"		30 MIN	7.7 GRMS RANDOM ACR SPEC. INLET: 7.5gRMS TRI-AX: 5.0gRMS
	4/9/80				
6	0937	LATERAL		5 MIN	10-100 HZ @ 2.0g PLOTTING INLET HOUSING ACC.
7	0944	"		5 MIN	100-10 HZ @ 2.0g PLOTTING TRI-AX ACC.
8	1018	"		30 MIN	DWELL @ 100 HZ 2.0g INLET: 8.4g TRI-AX: 5.8g
9	1052	"		30 MIN	DWELL @ 79 HZ 2.0g INLET: 7.5g TRI-AX: 6.0g
10	1140	"		30 MIN	7.4 GRMS RANDOM INLET: 4.8 gRMS TRI-AX: 4.1 gRMS
11	1250	"		10 MIN	BARE SLIP PLATE FOR SYSTEM CHECKOUT BETWEEN AXIS.
12	1345	AXIAL		30 MIN	7.2 GRMS RANDOM INLET: 5.6 gRMS TRI-AX: 5.4 gRMS

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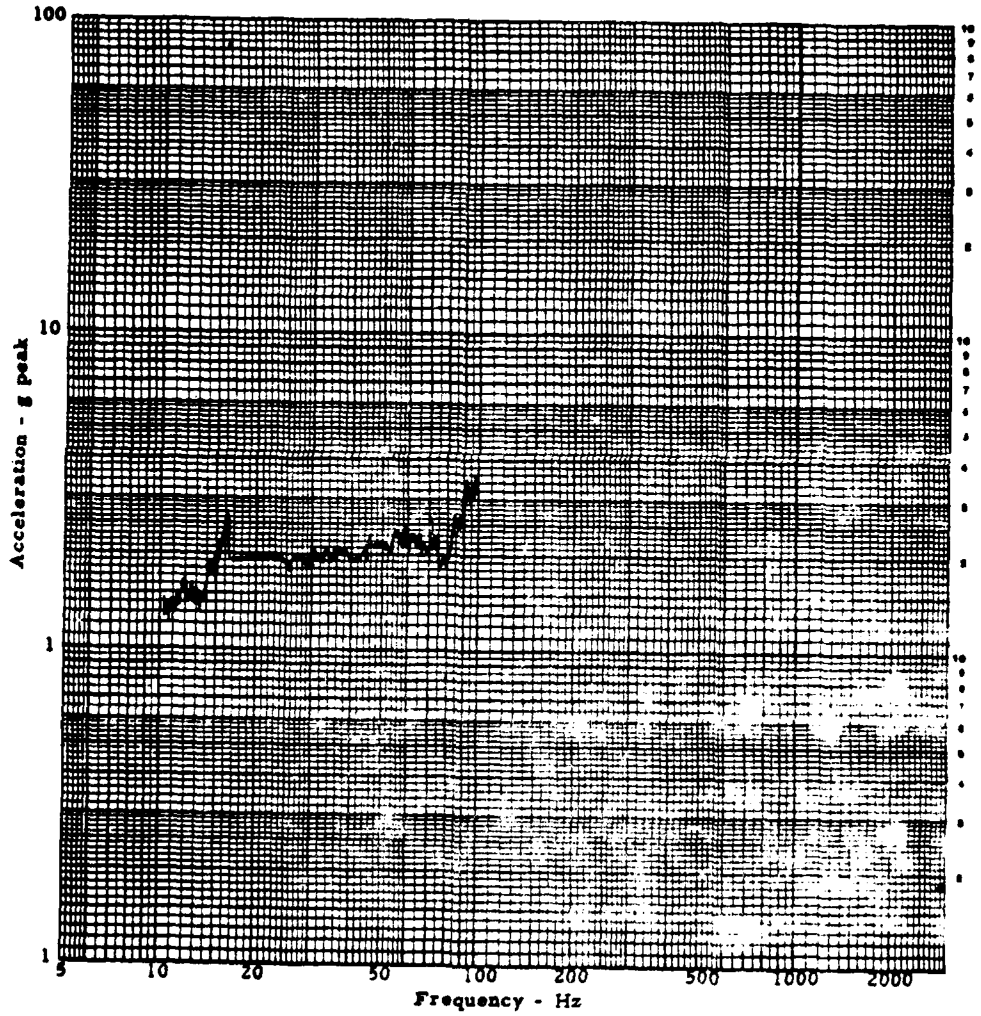
Bendix
Aerospace Systems Operations

TR
FIGURE /

VIBRATION LEVELS

Test Item: WRC ENGINE F107-WR-400
Test Date: 4/8/80

Serial Number: 828-704
Input Axis: VERTICAL
Response Axis: INLET HOUSING



440-8 A

SEQ. 1

Bendix

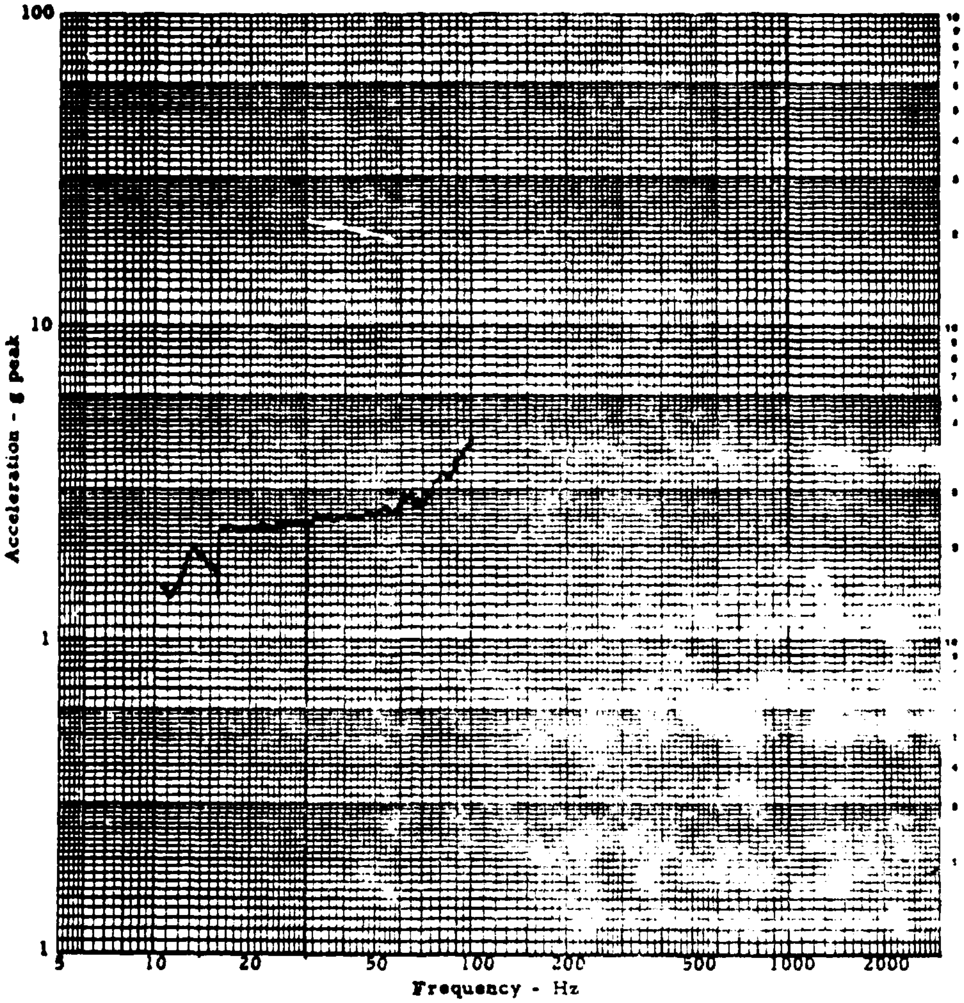
Aerospace Systems Operations

TR
FIGURE 2

VIBRATION LEVELS

Test Item: WRC ENGINE FIXTURE-400
Test Date: 4-8-80

Serial Number: 228 704
Input Axis: VERTICAL
Response Axis: TRI-AXIAL



440-8 A

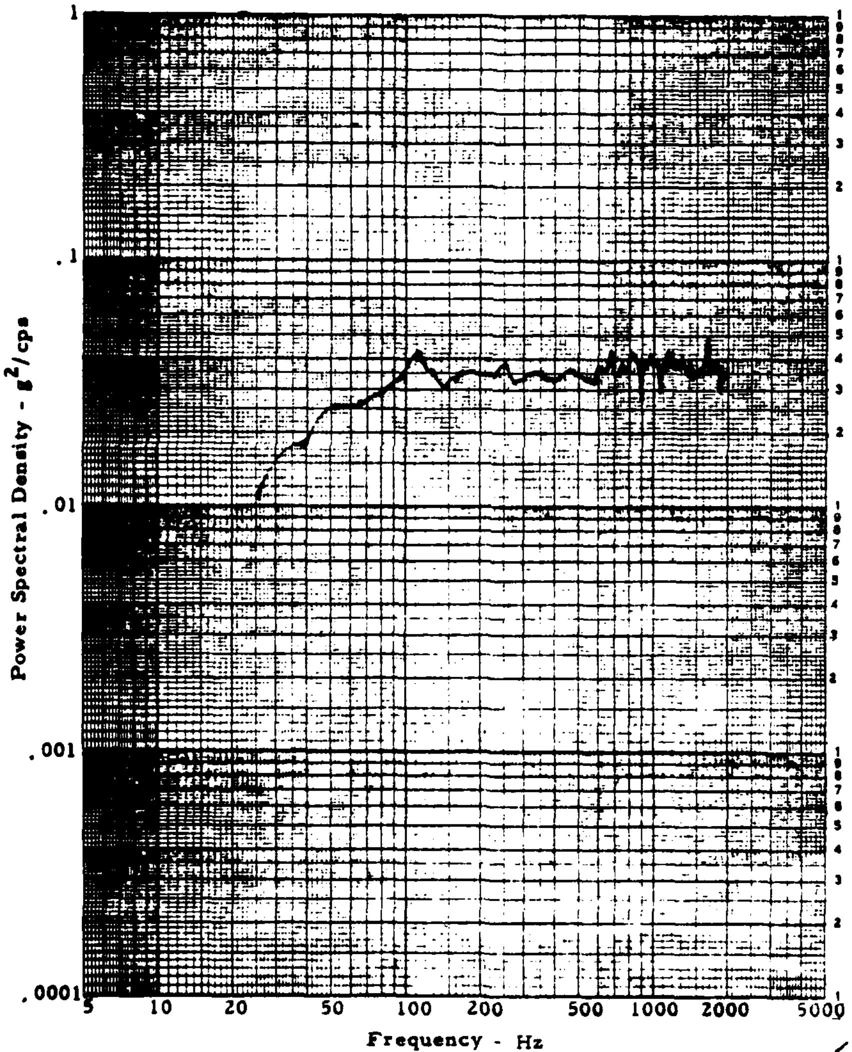
S&Q.2

SYSTEMS TEST DEPARTMENT

TR
Figure 3

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE FR-107-WR-400 SN: 838704
Test Date: 4-8-80 Axis: VERTICAL



440-13A

SEQ. 5
START of
TEST

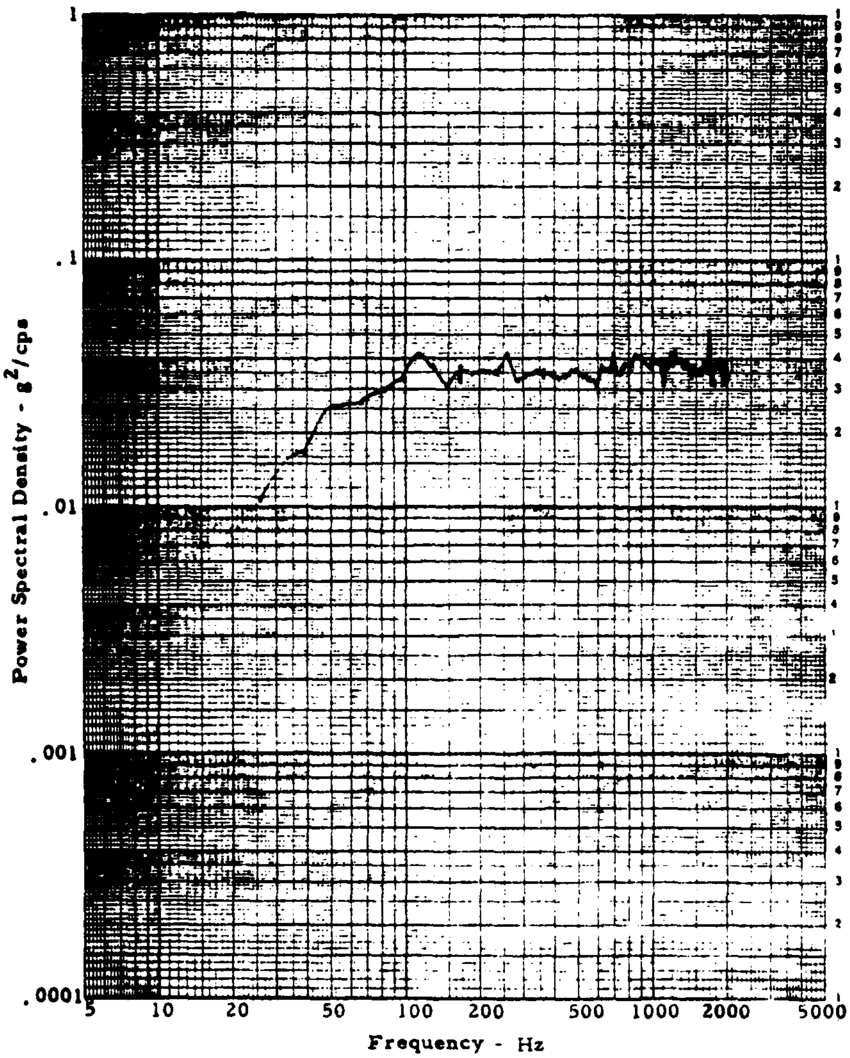
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 4

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE FR-107-WR-400   SN: 234-704
Test Date: 4-8-80   Axis: VERTICAL



440-13A

SEQ. 5
END OF TEST

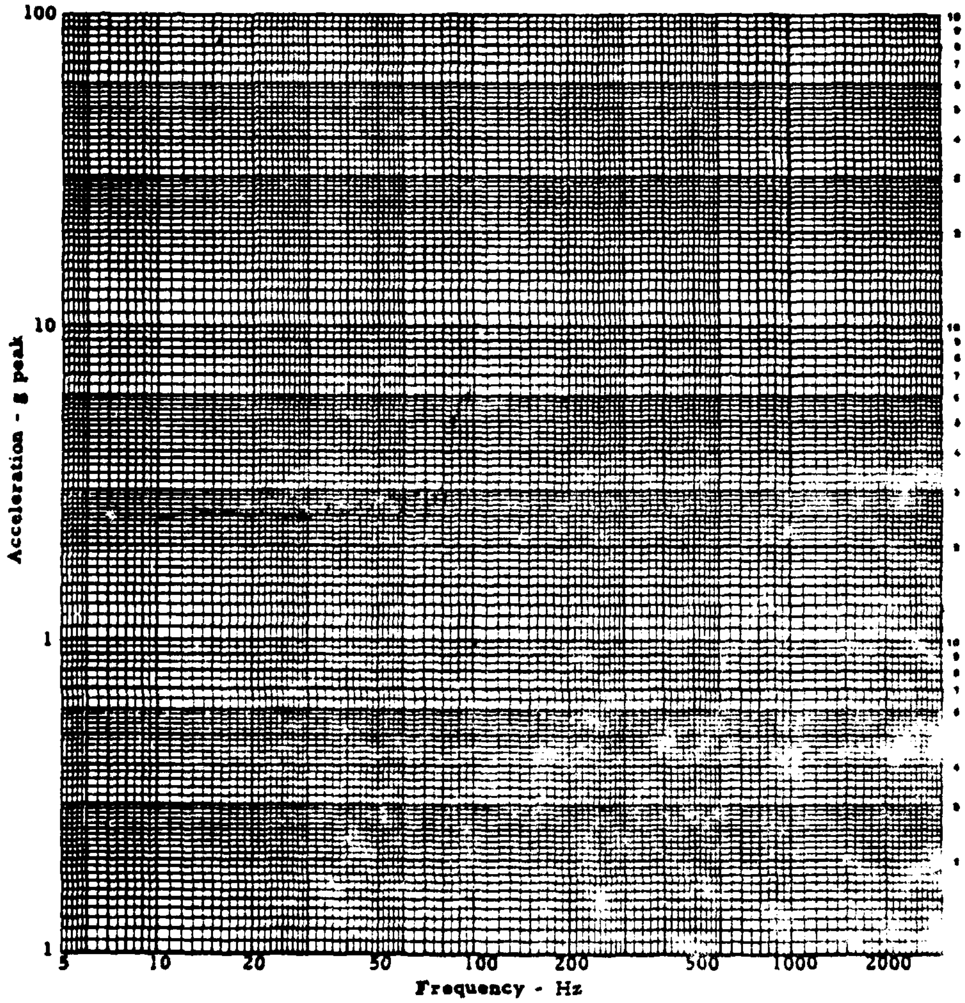
Bendix
Aerospace Systems Operations

TR FIGURE 15

VIBRATION LEVELS

Test Item: WRC ENGINE F107-WR-400
Test Date: 4/9/80

Serial Number: ~~838~~ 704
Input Axis: LATERAL (Y)
Response Axis: INLET HOUSING



440-8 A

SEQ. 6

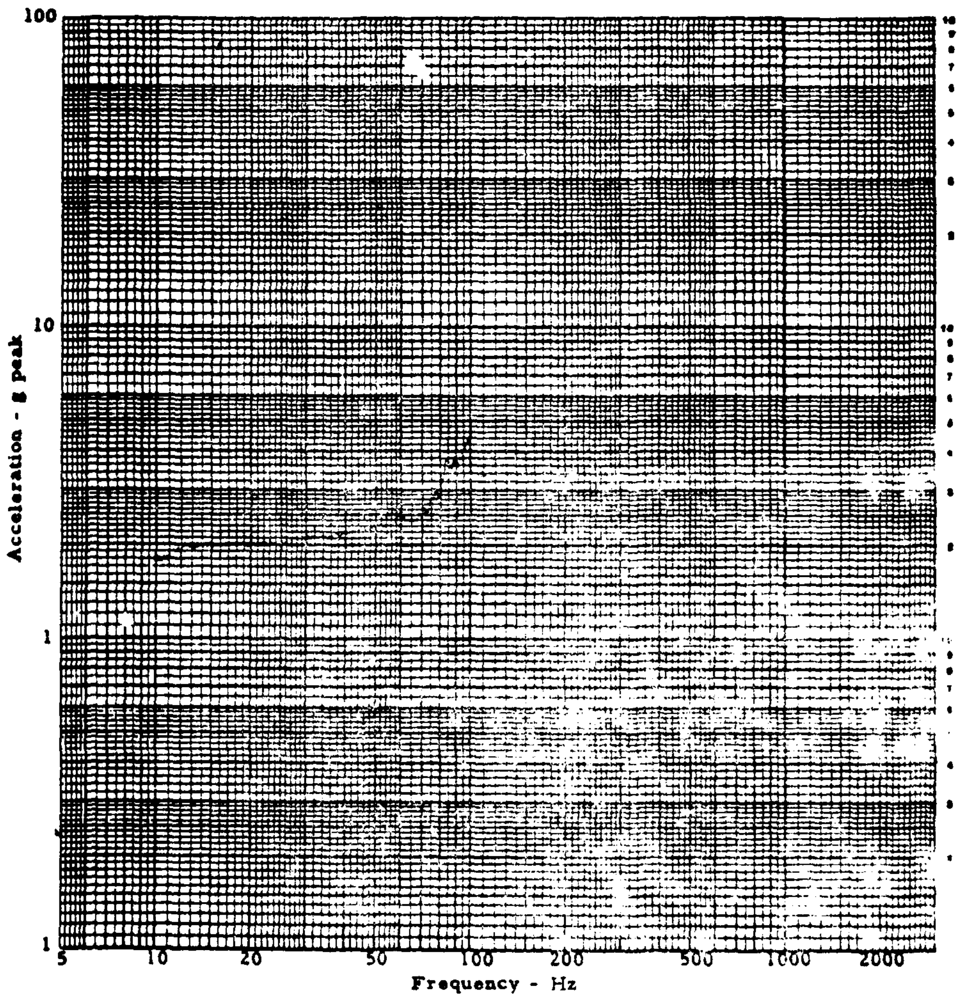
Bendix
Aerospace Systems Operations

TR FIGURE 6

VIBRATION LEVELS

Test Item: WRC ENGINE F107-WR-400
Test Date: 4/9/80

Serial Number: ~~738~~ 704
Input Axis: LATERAL (Y)
Response Axis: TRIAXIAL (Y)



440-8 A

Williams Research Corporation

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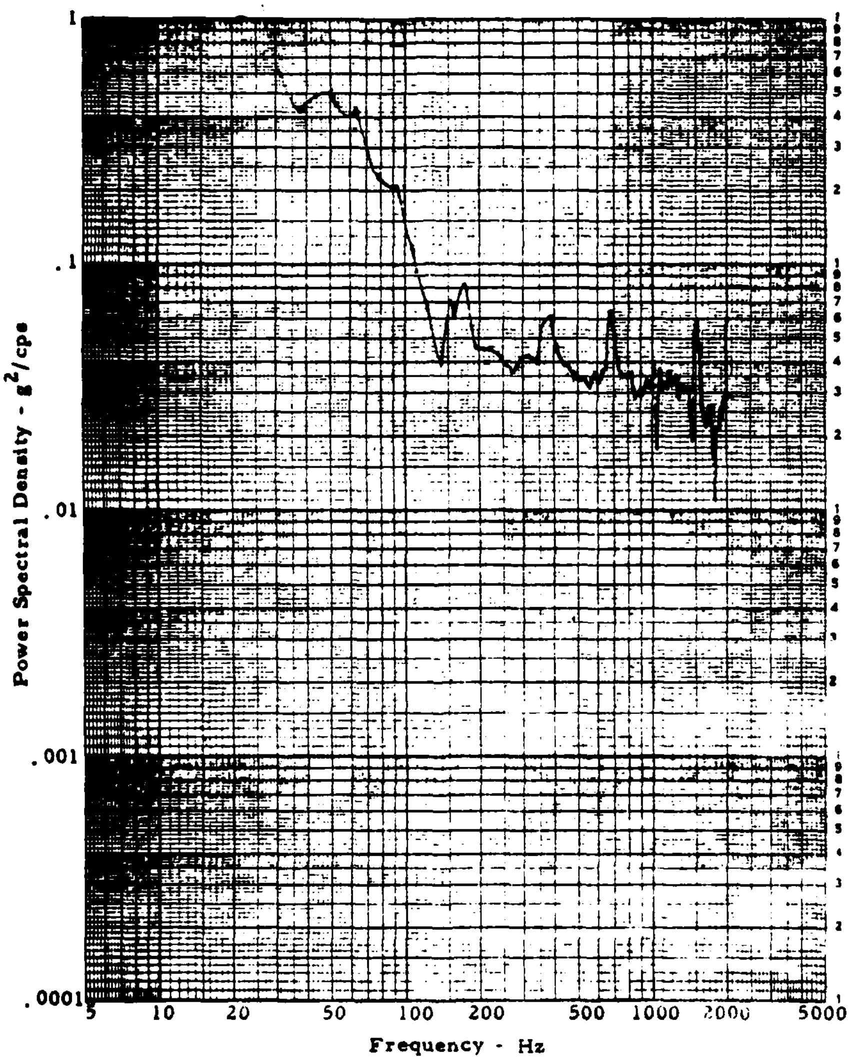
Report No. 79-106-39

SYSTEMS TEST DEPARTMENT

TR
Figure 7

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE F107-WR-400 SN: ~~838~~ 704
Test Date: 4/9/80 Axis: LATERAL



440-13A

SEQ. 10
START of TEST

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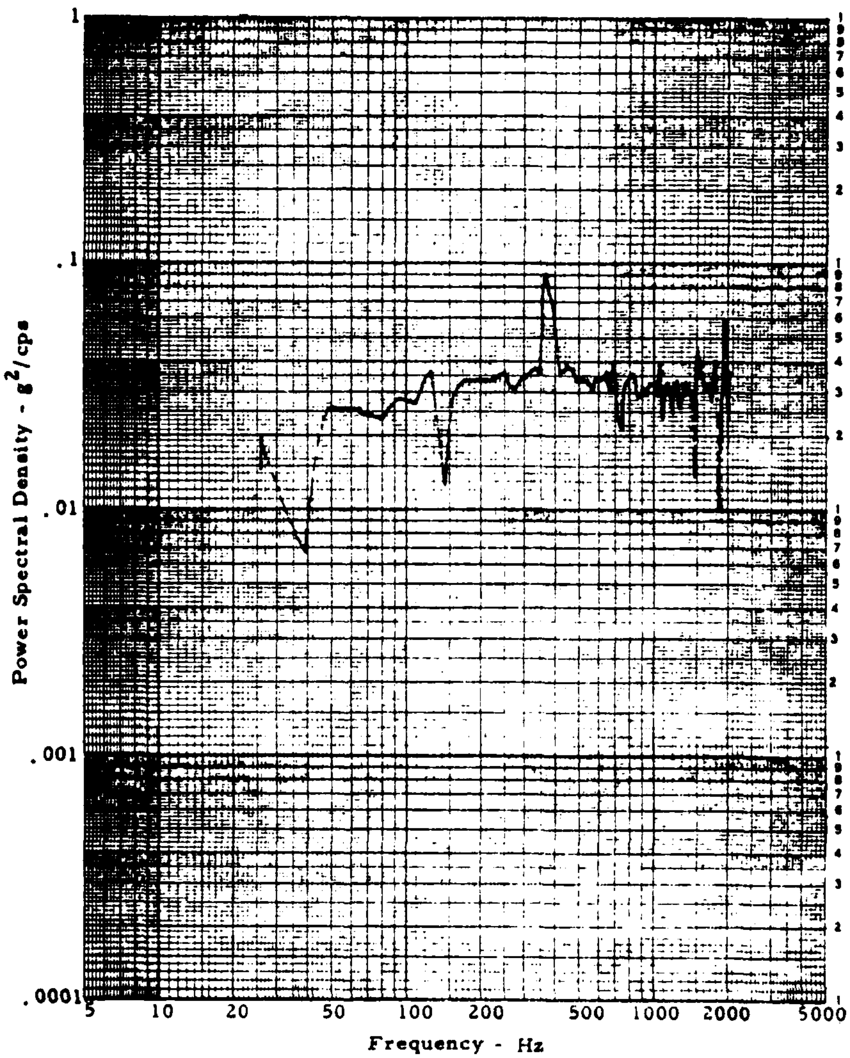
Report No. 79-106-39

SYSTEMS TEST DEPARTMENT

TR
Figure 8

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC. ENGINE F-107-WR-400 SN: 704
Test Date: 4/9/80 Axis: LATERAL



SEQ. 10
MID TEST.

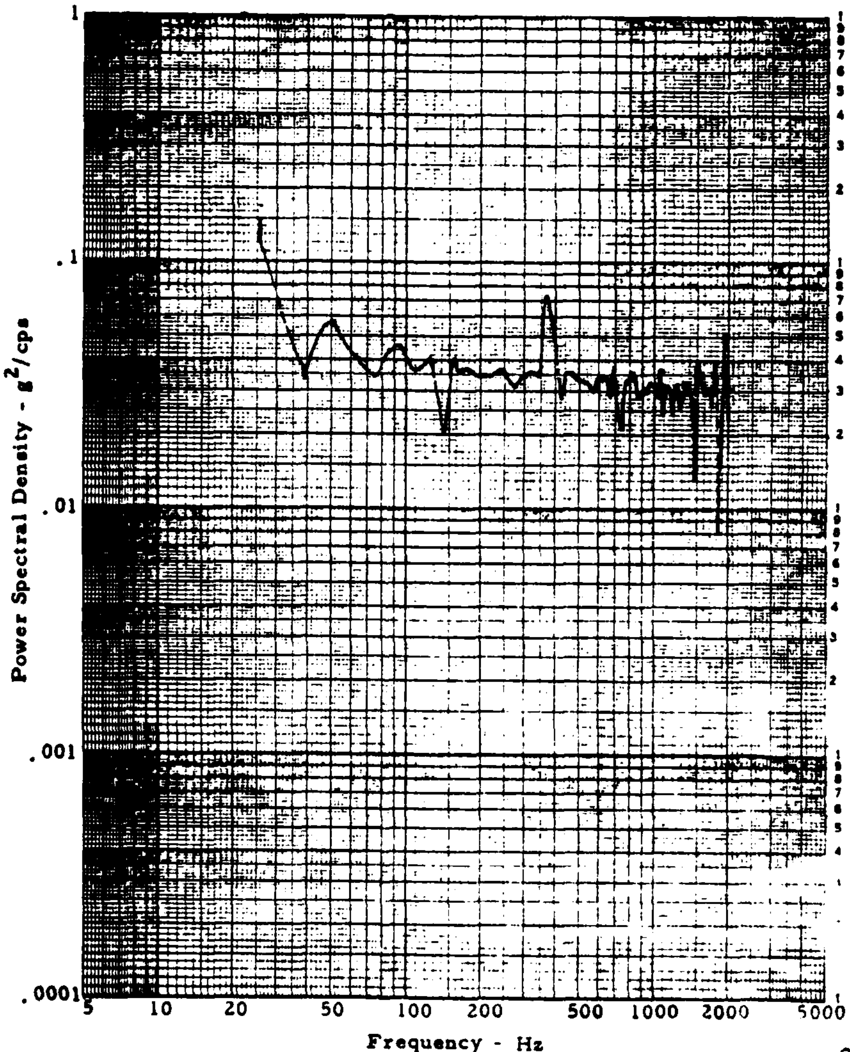
440-13A

SYSTEMS TEST DEPARTMENT

TR
Figure 9

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE F-107-WR-400 SN: 704
Test Date: 4/5/80 Axis: LATERAL



SEQ. 10 of END TEST

440-13A

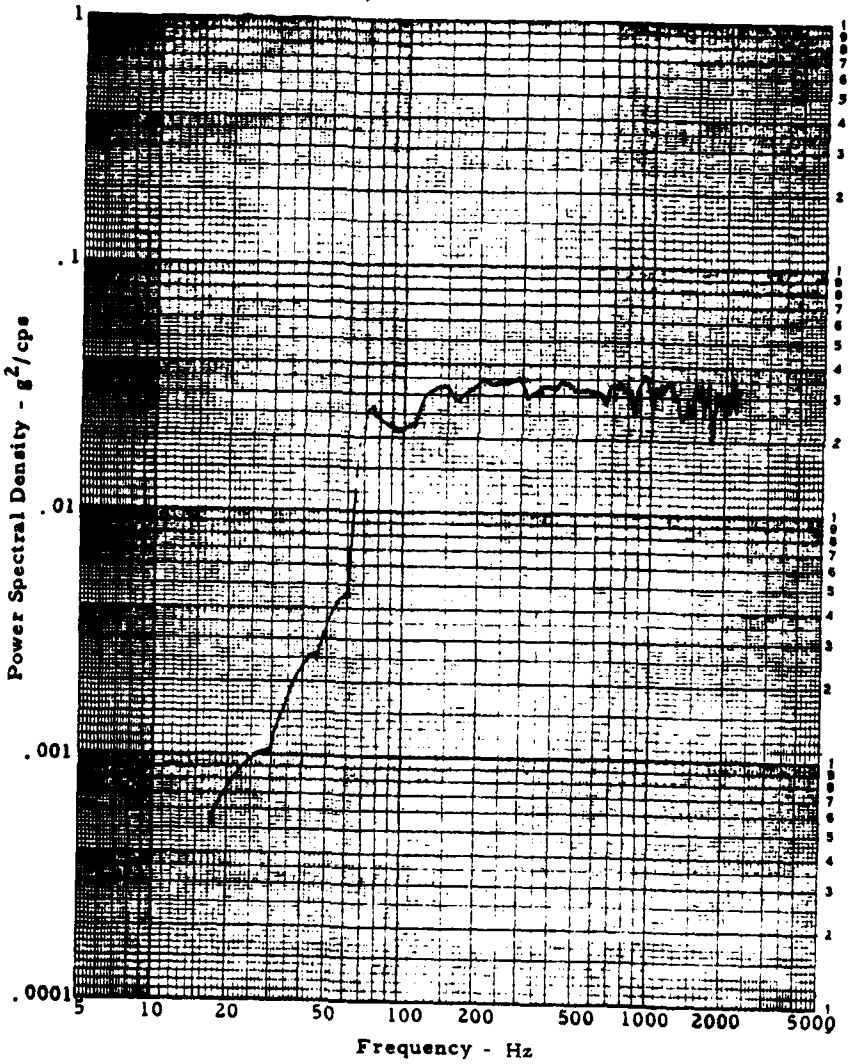
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 10

RANDOM VIBRATION SPECTRUM

Test: SYSTEM CHECK (QUICK CHECK EQUALIZER FILTERS NOT FINE TUNED)
Test Item: BARE SLIP PLATE (4')
SN:
Test Date: 4 9 81
Axis:



440-13A

SEQ.11

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

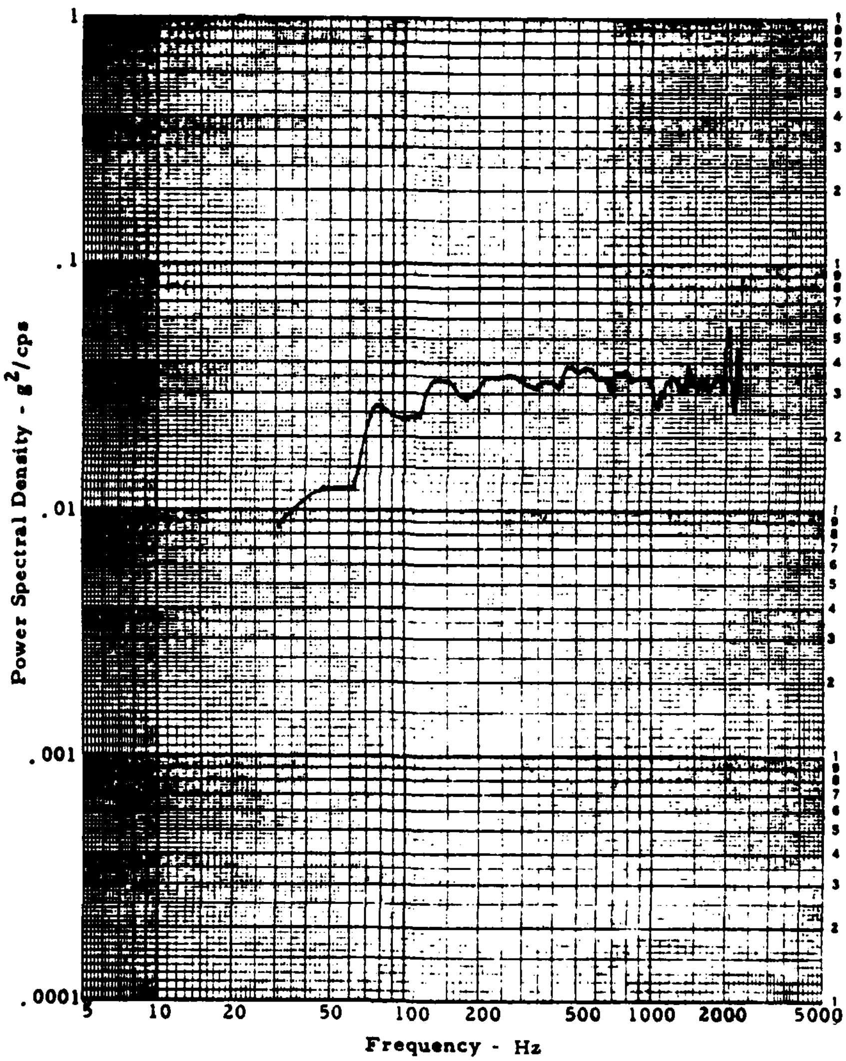
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

TR
Figure 11

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE F107-WR-400 SN: 706
Test Date: 4-9-80 Axis: AXIAL



440-13A

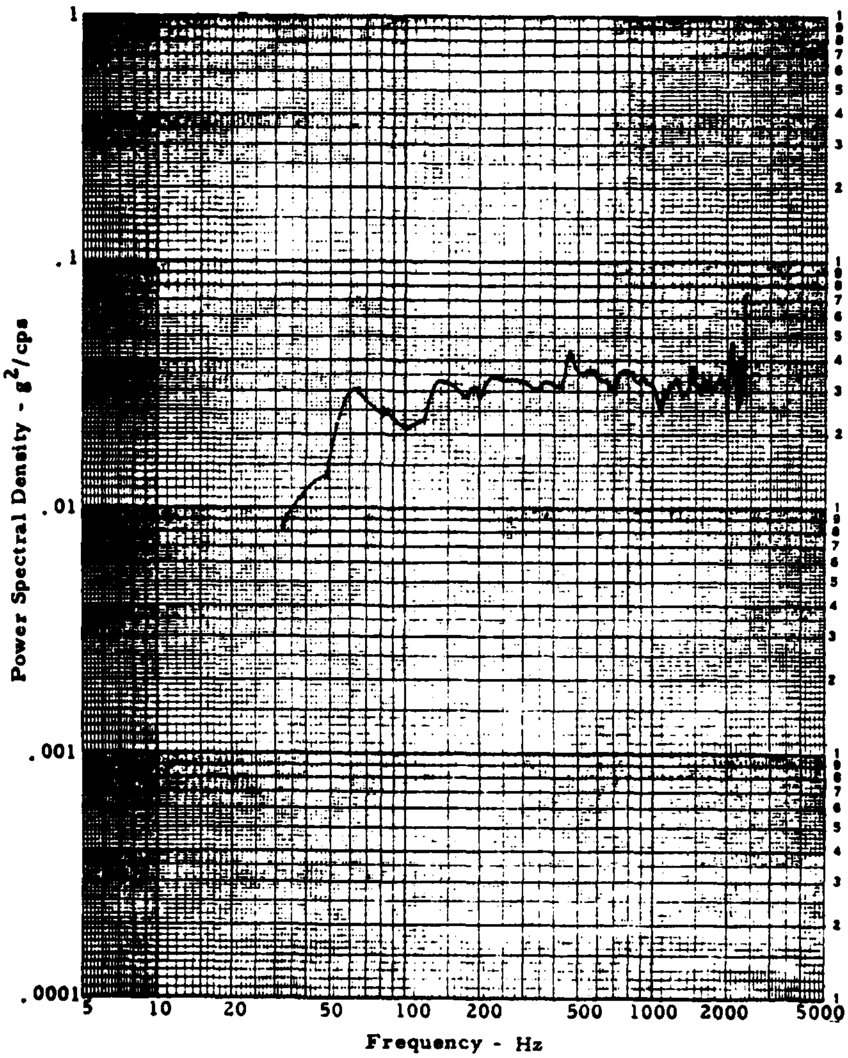
SEQ. 12
START of TEST

SYSTEMS TEST DEPARTMENT

TR
Figure /2

RANDOM VIBRATION SPECTRUM

Test:
Test Item: WRC ENGINE F-107-WR-400 SN: 400
Test Date: 5 9 80 Axis: AXIAL



440-13A

SEQ. 12
END of TEST

APPENDIX E

PRE AND POST-TEST CALIBRATION DATA FOR THE FUEL CONTROL UNIT AND FUEL SHUTOFF VALVE

This appendix contains pre- and post-test calibration data for the fuel control unit and fuel shutoff valve used on Engine 828/ build 6 during the hot and cold day mission simulation tests. The fuel control unit represented here (S/N 1443454) is the unit installed on the engine at AEDC as a replacement after the failure of the fuel control unit originally installed on the engine.

Woodward Governor Company
Rockford, Illinois

TSP- 1730
Page 1 of 7 REV. NEW

WOODWARD GOVERNOR COMPANY TEST SPECIFICATION FOR 83209 - FUEL CONTROL
MIL-C-7024 Type II Calibrating Fluid

Case No. 42

W.G. S/N 1443454 W.G. Order: [illegible]

Customer: Williams Research Contract No.: ____________

Woodward P/N	Williams P/N
8061-056	36240

FROM ENGINE 828. PRE ENGINE QT CALIBRATION

Date [illegible] Tested By [illegible] Test Stand No. 132

Sensor No. 62

1.0 Test Conditions ACT. 108

1.1 The following conditions shall be maintained for the entire test.

1.1.1 Control supply fuel pressure (P_S) = 20 psig supply.
1.1.2 Ambient air temp = 70±10°F.
1.1.3 Ambient pressure = 14.7±1 psia.
1.1.4 *Pressurizing Valve: A remote pressurizing* valve set to 80 psi above P_{bc} should be used in the metered flow line.
1.1.5 Back pressure controller. Downstream of the pressurizing valve use a pressure regulator referenced to CDP and downstream of an orifice calibrated to give 144 psi ΔP at 400 pph.

1.2 Test Equipment

1.2.1 15 HP variable speed stand, 13,000 rpm, .05% speed control.
1.2.2 30 PPH - 600 PPH flowmeter 0.5% accuracy (2 required).
1.2.3 0-50 PSI ΔP gauge ± .25 psi accuracy (P_1-P_2).
1.2.4 0-800 psig pressure gauge ±10 psi accuracy (P_1).
1.2.5 0-300 psia pressure gauge .2 psi reading accuracy (CDP).
1.2.6 0-800 psig pressure gauge ±10 psi accuracy (P_2).
1.2.7 0-800 psig pressure gauge ±10 psi accuracy (P_N).
1.2.8 0-100 psig pressure gauge ±1 psi accuracy (P_{bc}).

1.3 All control settings should be made while approaching the set points as follows, unless otherwise specified.

1.3.1 Engine inlet temperature simulator or sensor-approach set temperature from a lower temperature.
1.3.2 Compressor discharge pressure-approach set point from a lower pressure. Hysteresis checks should be approached from a higher pressure.
1.3.3 Speed setting voltage-approach from a numerically lower value unless otherwise specified.
1.3.4 Do not overshoot set point. If set point is overshot, reduce or increase input signal, depending on requirement and approach set point again.

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	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS	ACTUAL

2.0 Functional

2.1 Pump Capacity

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS	ACTUAL
	1455 ±10	Set	.620 (60°)	3.6	P_1=120 + P_s (ΔP<10 psi)	95 PPH min.	142

2.2 Ultimate

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS	ACTUAL
	11000 ±200	150	.620 (60°)	3.6	Stopcock Flow for max. of 2 seconds Record valve cracking pressure	725-775 psid (P_1-P_s)	750

2.3 Built In-Test

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS	ACTUAL
2.3.1				-10	Record BIT Signal Voltage	12.64-14.64	13.67
2.3.2				-7.0		9.91-11.91	10.92
2.3.3				0		3.5-5.5	4.56
2.3.4				3.5		.36-2.36	1.37

3.0 Power Lever Schedule

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	RPM Min.	RPM Nom.	RPM Max.	ACTUAL
3.1		95	.620(60°F)	-5	Set to 129 PPH	9725	9924	10123	9825
3.2		138		-2	Set to 207 PPH	10644	10833	11022	10774
3.3		180		1	Set to 307 PPH	11423	11539	11554	11483
3.4		209		3.5	Set to 387 PPH	11994	12024	12054	12014
3.5		209		4.012	Set to 387 PPH	11994	12024	12054	* 12014
3.6		209			Set T.P. 3.4 Reduce P/L V to 382 PPH	3.1V		3.4V	3.32V

* - To be within 10 rpm of setting in para 3.4.

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	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS			ACTUAL
4.0	Temperature Override Schedule					RPM			
						Min.	Nom.	Max.	
4.1		46	.591 (0°)	3.6	Set 81 PPH	11733	11793	11853	11794
4.2		48	.574 (-35°F)	3.6	Set 82 PPH	11444	11519	11594	11550
4.3		50	.5595 (-65°)	3.6	Set 83 PPH	11191	11281	11371	11359
4.4		209	.591 (0°)	3.6	Set 390 PPH	11763	11823	11883	11790
4.5		209	.574(-35°)	3.6	Set 384 PPH	11483	11558	11633	11547
4.6		209	.5595(-65°)	3.6	Set 380 PPH	11233	11323	11413	11355

5.0 Accel, Decel, Max. & Start Flow Altitude

5.1 Accel 60°F

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	P_1-P_2 ΔP	Flow Min.	Flow Nom.	Flow Max.	ACTUAL
5.1.1	7100	40	.620(60°)	3.6		30	84	88	93	88
5.1.2	7100	40		-7.0		30	84	88	93	85
5.1.3	10700	120		3.6		31.9	257	266	275	264
5.1.4	11500	180				32.5	384	398	411	397
5.1.5	11500	200				32.5	427	442	458	440
5.1.6	10700	120	▼	▼	Hysteresis	31.9	257	266	275	266

5.2 Max. Flow

5.2.1	11500	250	.620(60°)	3.6		443	448	453	449

5.3 Accel 170°F

5.3.1	5000	30	.679(170°)	3.6		68	73	78	74.5
5.3.2	11500	180	.679(170°)	3.6		423	439	454	433

5.4 Accel -65°F

5.4.1	6400	40	.5595 (-65°F)	3.6		73	77	82	77
5.4.2	10300	220	.5595 (-65°F)	3.6		409	424	439	430

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	SPEED RPM*	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS			ACTUAL
5.5	Decel Schedule					RPM			
						MIN.	NOM.	MAX.	
5.5.1	12024	160	.620(60°)	-7.0		146	153	161	152
5.5.2	12024	100	.620(60°)	-7.0		90	96	101	94
5.6	Starting Flow								
5.5.1	1455	14.7	.620(60°)	-7.0		58	61	64	59.5
5.6.2	8244	14.7	.620(60°)	-7.0		58	63	67	63.5
5.7	Altitude Schedule								
5.7.1	11100	40	.620(60°)	3.6		84	88	93	89
6.0	Altitude Governor Schedule								
6.1		62	.620(60°)	3.6	97 PPH	11964-12084 RPM			12034
6.2		107	.620(60°)	3.6	187 PPH	11964-12084 RPM			12029
7.0	Governor Gain								
7.1		209	.620(60°)	3.6	Speed below 11000. Raise to 11964 rpm.	Record W_f			408
7.2					Increase RPM to 12024	Record W_f			384
7.3					Increase RPM to 12265	Record W_f			280
7.4					Lower RPM to W_f in 7.2	12004 - 12034 RPM			12017
7.5					7.1 minus 7.3	109-164 PPH			128

*All speed settings ±100 RPM except test 5.6.1 ±10.

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS			ACTUAL
8.0	Idle Speed Setting					Speed Min.	Nom.	Max.	
8.1	10000	72	.620(60°)	-7.0	Reduce Speed to give 95 PPH & Record	9190	9236	9282	9229
8.2	9000			-7.0	Inc. speed to give 95 PPH	9190	9236	9282	9238
8.3				-7.3	95 PPH	To be within 20 RPM of 8.2			9238
8.4					8.2 less 8.1 max. 40 RPM hysteresis	RECORD			9
9.0	Pump Unloading								
9.1	12024 ±200	240	.620(60°)	-7.0	Reduce P/L Voltage below -7.0 and record the voltage that W_f drops	-7.65 to -9.675 V			-8.76
9.2	12024 ±200	240	.620(60°)	-9.775	Reduce P/L Voltage to -9.775 & Record P_2-P_{bc}	15 PSI max.			5
10.0	Leak Checks								
10.1	12024 ±200	240	.620(60°)	3.5	Raise P_1 to Ult. setting -20 PSI	No external leakage after 3 min.			0
10.2	0	0	.620(60°)	-10	Boost = 50 PSIG seal leakage Reduce to 5 PSIG	None after 10 min. None after 10 min.			0 0
10.3	Check for shaft seal leakage during cal. for any 30 min. of normal calibration running.					1 cc. max. after 30 min.			0
11.0	Drive Torque								
	Drive torque will be measured with a torque wrench after the control has been run for a minimum of 5 minutes on the test stand and removed. This test does not have to be run in sequence and could be done after the remainder of the test procedure is completed.					15 in.lb. max.			7

TSP-1730 Page 6 REV. E

		Initial
12.0	Final Check List	
12.1	Set stops in electric actuator.	RCR
12.2	Epoxy actuator stop screws. Cone shape epoxy per ass'y dwg.	Bt
13.0	Ground Isolation & Stall Current Tests. (Ref. TSP-1665)	

	Condition	Meter Polarity	Limit		Meter Polarity	Limit	
13.1	SRS to 28V	+	50k min.	50.2			
13.2	28V to case	+	50k min.	∞	-	50k min.	∞
13.3	SRS to case	+	50k min.	∞	-	50k min.	∞

13.4 Stall Current at SRS-15VDC Limit (1.1 a max.) .91

E 13.5 Stall Current at SRS 5VDC. Limit (1.1 a max.) .90

13.6 Voltage at Max. Stop (Set 4.10 to 4.20) RECORD 4.15

E 13.7 Voltage at Shutoff Stop (Set -10.40 to -10.50) RECORD -10.47

CHG. LET.	E/C NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
E	83070	NW	E	D	E	E	E	E							
D	83047	NW	C	D	A	C	D	D							
C	83001	NW	C	B	A	C	C	B							
B	76954	NW	B	B	A	NW	B	B							
A	76921-2	NW	A	A	A	NW	A	NW							
NEW	76921-1	NW	NW	NW	NW	NW	NW	NW							
		SHEET NUMBERS													

REVISION STATUS

Woodward Governor Company
Rockford, Illinois

TSP-1730
Page 7 REV. E

ACCEPTANCE TEST AUDIT

CASE # 42

Operator [illegible] Inspector M. Hilleon

S/N 144354 Date 80-2-29

Test Point	Min.	Max.	RECORD	REMARKS
3 2.1	95 pph	---	146	Pump Capacity
3.4	11994	12054	12035	100% Speed
4.1	11733	11853	11811	Speed Reset
4.5	11483	11633	11567	Speed reset
5.1.1	84	93	88	40 PSI Accel.
5.1.5	427	458	440	200 PSI Accel.
5.1.6	257	275	265	120 PSI Accel.
5.2.1	443	453	449	Max. Flow
5.5.1	146	161	154	Decel
5.6.1	58	64	58.5	Start Flow
E 7.2-7.4	12004	12034	12015	Hysteresis Check
8.1	9190	9282	9219	Idle Speed
10.1		None	0	External leakage after CIT Sensor Assembly
10.2		None	0	Static Leakage

DRudin:jb
79/5/15 ON TAPE

Woodward Governor Company
Rockford, Illinois

X83209-025

G32663

As received

WOODWARD GOVERNOR COMPANY TEST SPECIFICATION FOR 83209-CIT SENSOR (ATP) VALVE
MIL-C 7024A TYPE II CALIBRATING FLUID

SERVICE LIMITS

IDENTIFICATION NO. 62

Customer Williams Research Corp.

X83209-D25

Woodward P/N	Chk		Chk
X83209-0155		8901-140	
X83209-0201		8901-148	
X83209-031		8901-150	✓
8901-126	x		

Date 79-1220 Tested By WE Test Stand No. 71

Calibration to be recorded using fixture WT65650

Desired * ±1/2°	Min.	Max.	Actual
-65	.557	.562	.557
0	.5885	.5935	.590
75	.6235	.6325	.627
170	.6745	.6835	.679
75	.6235	.6325	.627
-65	.557	.562	.557

Signed W English Dated 79-12-20

*Correction:

If temperature pots are not within ± 1/2°F:

Add .0005" for each 1°F error below desired temperature.

Subtract .0005" for each 1°F error above desired temperature.

Rockford, Illinois

Rev. "NEW"
78-2-9
D.L. Jacobson
Sheet 3

DATA SHEET
PRESET TEST SPECIFICATION
FOR 8901-130 SHUTOFF VALVE

W.R.S/N RE 147978Z CASE NO. 109

DATE 15 July 78 TESTED BY JKW

1. Increase supply pressure (P_2) slowly until valve cracks open, noting the pressure at which it cracks.
   Record P_2 which cracks valve 95 PSIG
   $P_2 - P_{bc}$ = 75 PSIG
   $P_2 - P_{bc}$ = 110 PSIG Max.

2. Decrease supply pressure (P_2) until discharge flow (W_f) is 60 PPH.
   Record P_2 here as P_{21} 99 PSIG

   Increase supply pressure (P_2) until discharge flow (W_f) is 60 PPH.
   Record P_2 here as P_{22} 108 PSIG 105

   $P_{22} - P_{21}$ = 9 PSIG Hyst.

   $P_{22} - P_{21}$ = 35 PSIG max. allowable hysteresis

3. Increase supply pressure (P_2) until discharge flow (W_f) is 500 PPH.

   Record supply pressure (P_2) 155 PSIG
   Record discharge pressure (P_n) 18 PSIG

   $P_2 - P_n$ = 137 PSIG
   $P_2 - P_n$ = 150 psig max.

4. Check discharge leakage for three (3) minutes.

   Record NONE

   Max. Allowed 0

FROM ENGINE 828. PRE ENGINE QT CALIBRATION

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

SERVICE LIMITS

WOODWARD GOVERNOR COMPANY TEST SPECIFICATION FOR 83209 - FUEL CONTROL
MIL-C-7024A Type II Calibrating Fluid

Case No. 42

W.G. S/N [illegible]3454 W.G. Order ________

Customer: Williams Research Contract No.: ________

FROM ENGINE 828. POST QT CAL. (A)

Woodward P/N	Williams P/N	
8061-003	29977	
8061-009	23560	
8061-056	36240	

Witnessed for as Received 10 May 80

Date [illegible] Tested By [illegible] Test Stand No. 122

Sensor No. 62

1.0 Test Conditions

1.1 The following conditions shall be maintained for the entire test.

1.1.1 Control supply fuel pressure (P_s) = 20 psig supply.
1.1.2 Ambient air temp = 70±10°F.
1.1.3 Ambient pressure = 14.7±1 psia.
1.1.4 Pressurizing Valve: A remote pressurizing valve set to 80 psi above P_{bc} should be used in the metered flow line.
1.1.5 Back pressure controller. Downstream of the pressurizing valve use a pressure regulator referenced to CDP and downstream of an orifice calibrated to give 144 psi ΔP at 400 pph.
1.1.6 Rotation of Drive Shaft - CW (Looking at end of Drive Shaft).

1.2 Test Equipment

1.2.1 15 HP variable speed stand, 13,000 rpm, .05% speed control.
1.2.2 30 PPH - 600 PPH flowmeter 0.5% accuracy (2 required).
1.2.3 0-50 PSI ΔP gauge ± .25 psi accuracy (P_1-P_2).
1.2.4 0-800 psig pressure gauge ±10 psi accuracy (P_1).
1.2.5 0-300 psia pressure gauge .2 psi reading accuracy (CDP).
1.2.6 0-800 psig pressure gauge ±10 psi accuracy (P_2).
1.2.7 0-800 psig pressure gauge ±10 psi accuracy (P_N).
1.2.8 0-100 psig pressure gauge ±1 psi accuracy (P_{bc}).

1.3 All control settings should be made while approaching the set points as follows, unless otherwise specified.

1.3.1 Engine inlet temperature simulator or sensor-approach set temperature from a lower temperature.
1.3.2 Compressor discharge pressure-approach set point from a lower pressure. Hysteresis checks should be approached from a higher pressure.
1.3.3 Speed setting voltage-approach from a numerically lower value unless otherwise specified.
1.3.4 Do not overshoot set point. If set point is overshot, reduce or increase input signal, depending on requirement and approach set point again.

X83209 - E68 Page 2 REV A

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS	ACTUAL
2.0	**Functional**						
2.1	**Pump Capacity**						
	1455 ±10	Set	.620 (60°)	3.6	P_1=120 + P_s (ΔP<10 psi)	80 PPH min.	146
2.2	**Ultimate**						
	11000 ±200	150	.620 (60°)	3.6	Stopcock Flow for max. of 2 seconds Record valve cracking pressure	600-700 psid (P_1 - P_s)	
					8061-056 ONLY	700-800 psid	750
2.3	**Built In Test**						
2.3.1				-10	Record BIT Signal Voltage	12.14-15.14	13.68
2.3.2				-7.0		9.41-12.41	10.[illegible]
2.3.3				0		3.0-6.0	4.54
2.3.4				3.5		.36-2.86	1.35

	SPEED RPM	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	RPM Min.	RPM Nom.	RPM Max.	ACTUAL
3.0	**Power Lever Schedule**								
3.1		95	.620(60°F)	-5	Set to 129 PPH	9523	9924	10325	9836 [illegible]
3.2		138		-2	Set to 207 PPH	10463	10833	11203	10791 [illegible]
3.3		180		1	Set to 307 PPH	11308	11539	11770	11498 11377
3.4*		209		3.5	Set to 387 PPH	11934	12024	12114	12021 [illegible]
3.5		209		3.8	Set to 387 PPH	11934	12024	12114	12021 [illegible]
3.6		209			Set T.P.3.4. Reduce P/L V to 382 PPH	2.7V		3.9V	3.31 [illegible]
4.0	**Temperature Override Schedule**								
4.1		46	.591 (0°)	3.6	Set 81 PPH	11673	11793	11913	11791 [illegible]
4.2		48	.574 (-35°F)	3.6	Set 82 PPH	11369	11519	11669	11544 [illegible]
4.3		50	.5595 (-65°)	3.6	Set 83 PPH	11127	11281	11487	11357 [illegible]
4.4		209	.591 (0°)	3.6	Set 390 PPH	11703	11823	11943	11795
4.5		209	.574(-35°)	3.6	Set 384 PPH	11408	11558	11708	11550
4.6		209	.5595(-65°)	3.6	Set 380 PPH	11169	11323	11529	11375

* If max speed setting is beyond limits, after completing as received test, readjust max speed within limits and retest paragraphs 3,4,6&7,8

X83209 - D68 Page 3 REV A

	SPEED RPM △	CDP PSIA	T_2 INCHES	P/L VDC	NOTES	LIMITS				ACTUAL
5.0	Accel, Decel, Max. & Start Flow Altitude									
							Flow			
5.1	Accel 60°F					P_1-P_2 ΔP	Min.	Nom.	Max.	
5.1.1	7100	40	.620(60°)	3.6		28.7	78	88	98	[illegible]
5.1.2	7100	40	↓	-7.0		28.7	78	88	98	[illegible]
5.1.3	10700	120		3.6		30.8	252	266	280	271
5.1.4	11500	180		↓		31.2	377	398	418	400
5.1.5	11500	200				31.2	419	442	466	440
5.1.6	10700	120			Hysteresis	30.8	250	266	282	270
5.2	Max. Flow									
5.2.1	11500	250	.620(60°)	3.6			485	500	515	
5.3	Accel 170°F				8061-056 ONLY		438	448	458	452
5.3.1	5000	30	.679(170°)	3.6			67	73	83	78.5
5.3.2	11500	180	.679(170°)	3.6			415	439	462	433
5.4	Accel -65°F									
5.4.1	6400	40	.5595 (-65°F)	3.6			67	77	87	81
5.4.2	10300	220	.5595 (-65°F)	3.6			401	424	447	435
5.5	Decel Schedule									
5.5.1	12024	160	.620(60°)	-7.0			136	153	171	153
5.5.2	12024	100	.620(60°)	-7.0			84	96	108	94
5.6	Starting Flow									
5.6.1	1455	14.7	.620(60°)	-7.0			53	61	69	58
5.6.2	8244	14.7	.620(60°)	-7.0			52	63	72	63.5
5.7	Altitude Schedule									
5.7.1	11100	40	.620(60°)	3.6			78	88	98	[illegible]

△ All speed settings ±100 RPM except test 5.6.1 ±10.

X83209 - D68 Page 4 REV A

	Speed RPM	CDP PSIA	T_2 Inches	P/L VDC	Notes	Limits	ACTUAL
.0	**Altitude Governor Schedule**						
.1		62	.620(60°)	3.6	97 PPH	11904-12144 RPM	12049 11928
.2		107	↓	↓	187 PPH	11904-12144 RPM	12039 [illegible]
~~.3~~		~~240~~			~~448 PPH~~	~~11904-12144 RPM~~	
.0	**Governor Gain**						
.1		209	.620(60°)	3.6	Speed below 11000. Raise to 11964 rpm.	Record W_f	406 360
.2					Increase RPM to 12024	Record W_f	384 339
.3					Increase RPM to 12265	Record W_f	280 222
.4		↓	↓	↓	Lower RPM to W_f in 7.2	11944 Min.	12015 12005
.5					7.1 minus 7.3	99-174 PPH	123 126

	Speed RPM	CDP PSIA	T_2 Inches	P/L VDC	Notes	Speed Min.	Speed Nom.	Speed Max.	ACTUAL
,0	**Idle Speed Setting**								
.1	10000	72	.620(60°)	-7.0	Reduce Speed to give 95 PPH & Record	9130	9236	9332	9236 9207
.2	9000			-7.0	Inc. speed to give 95 PPH	9130	9236	9332	9240 9212
.3		↓	↓		8.2 less 8.1 max. 40 RPM hysteresis	RECORD			4 5

A		A	A	A	A	NW									
CHG. LET.	E/C NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		SHEET NUMBERS													
REVISION STATUS															

Woodward Governor Company
Rockford, Illinois

X83209 - D68
Page 5 of 5 REV NEW

	Speed RPM	CDP PSIA	T_2 Inches	P/L VDC	Notes	Limits	ACTUAL
.0	Pump Unloading						
3.1	12024 ±200	240	.620(60°)	-7.0	Reduce P/L Voltage below -7.0 and record the voltage that W_f drops	-7.4 to -9.9V	-8.83
.2	12024 ±200	240	.620(60°)	-10	Reduce P/L Voltage to -10 and record P_2-P_{bc}	30 PSI max.	3
0.0	Leak Checks						
0.1	12024 ±200	240	.620(60°)	3.5	Raise P_1 to Ult. setting -20 PSI	No external leakage after 3 min.	0
0.2	0	0	.620 (60°)	-10	Boost = 50 PSIG Seal Leakage	None after 10 min.	0
0.3	Check for shaft seal leakage during cal. for any 30 min. of normal calibration running.					2 CC Max. after 30 min.	0
1.0	Drive Torque						
	Drive torque will be measured with a torque wrench after the control has been run for a minimum of 5 minutes on the test stand and removed. This test does not have to be run in sequence and could be done after the remainder of the test procedure is completed.					20 in.lb.max.	6

2.0	Final Check List	Initial
2.1	Set stops in electric actuator.	
2.2	Epoxy actuator stop screws. Dome shape epoxy per ass'y dwg.	

3.0 Ground Isolation & Stall Current Tests. (Ref TSP-1665)

	Condition	Meter Polarity	Limit		Meter Polarity	Limit	
3.1	SRS to 28V	+	50k min	50.2			
3.2	28V to case	+	50k min	[illegible]	-	50k min	[illegible]
3.3	SRS to case	+	50k min	[illegible]	-	50k min	[illegible]

3.4	Stall Current at SRS-15VDC Limit (1.5 a max.)	.477
3.5	Stall Current at SRS 5VDC Limit (1.5 a max.)	.416

4.14
-10.47

Woodward Governor Company
Rockford, Illinois

X83209-025

as winner

WOODWARD GOVERNOR COMPANY TEST SPECIFICATION FOR 83209-CIT SENSOR (ATP) VALVE
MIL-C 7024A TYPE II CALIBRATING FLUID

SERVICE LIMITS

IDENTIFICATION NO. 62

Customer Williams Research Corp.

Woodward P/N	Chk		Chk
X83209-0155		8901-140	
X83209-0201		8901-148	
X83209-031		8901-150	
8901-128	✓		

Date 80-6-4 Tested By WE Test Stand No. 71

Calibration to be recorded using fixture WT65650

Desired* ±1/2°	Min.	Max.	Actual
-65	.557	.562	.557
0	.5885	.5935	.590
75	.6235	.6325	.6275
170	.6745	.6835	.680
75	.6235	.6325	.6275
-65	.557	.562	.557

Signed W Englert Dated 80-6-4

*Correction: .009

If temperature pots are not within ± 1/2°F:

Add .0005" for each 1°F error below desired temperature.

Subtract .0005" for each 1°F error above desired temperature.

Woodward Governor Company
Rockford, Illinois

TSP-1671
Page 3 of 5 Rev H

DATA SHEET FOR SHUTOFF VALVE

As Received

Woodward P/N	Williams P/N	Rev.
8901-162	34894	*
8901-130	29593	*
8901-146	23745	*
8901-161	34895	*

*See sales order for correct revision letter.

W.G. S/N RF1479797 P/N 8901-146 CASE NO. 109

DATE 21 mar 80 TESTED BY [illegible]

1. Increase supply pressure (P_2) slowly until valve cracks open, noting the pressure at which it cracks.
   Record P_2 which cracks valve 105 PSIG
   $P_2 - P_{bc}$ = 55 PSIG
   $P_2 - P_{bc}$ = 65-110 PSIG
   Shutoff $P_2 - P_{bc}$ = 33 (15 PSIG Min.)
2. Decrease supply pressure (P_2) until discharge flow (W_f) is 60 PPH.
   Record P_2 here as P_{21} 98 PSIG

   Increase supply pressure (P_2) until discharge flow (W_f) is 60 PPH.
   Record P_2 here as P_{22} 109 PSIG

   $P_2 - P_n$ = 106 PSIG
   $P_{22} - P_{21}$ = 11 PSIG Hyst.
   $P_{22} - P_{21}$ = 35 PSIG max. allowable hysteresis
3. Increase supply pressure (P_2) until discharge flow (W_f) is 500 PPH.

   Record supply pressure (P_2) 153 PSIG
   Record discharge pressure (P_n) 18 PSIG

   $P_2 - P_n$ = 135 PSIG
   $P_2 - P_n$ = 150 psig max.
4. Check discharge leakage for three (3) minutes.

   Record NONE

   Max. Allowed 0
5. Check discharge leakage for (3) minutes.

   Record NONE
   Max. allowed 0
6. Check discharge leakage for (3) minutes.

   Record NONE
   Max. allowed 0

FROM ENGINE 828. POST ENGINE QT CALIBRATION

APPENDIX F

FUEL CONTROL UNIT FAILURE ANALYSIS

This appendix presents both the preliminary and the final reports from the Woodward Governor Co. regarding the failure of fuel control unit S/N 1443446 during the hot day mission simulation testing of Engine 828 at AEDC. Also included is a copy of the report from Motorola Inc. (semiconductor component vendor) to the Woodward Governor Co. with reference to the failure of components internal to the fuel control unit.

WOODWARD GOVERNOR COMPANY
ROCKFORD, ILLINOIS

AIRCRAFT DIVISION

SPECIAL HANDLING REPORT

CUSTOMER Williams Research Corp. REPORT NO. EN 86853

CUSTOMER P.O. 124550 REQUESTED BY WASchrader DATE 80-4-3

W.O. S.O. G 36058 REPORTED BY S.E.Makulec

MODEL NO. 8061-056 S/N RF 1443446 DATE COMPLETED 80-4-10

CONTROL TYPE 83209

1. Problem Description (attach special reports, tests, lemos, etc.)

Actuator would not respond to input signal; would draw 3.4 amps on bench test with 28V supply.

PRELIMINARY REPORT

2. Special Instructions

A. Run "as received" test.
B. Investigate discrepancies.
C. If lengthy investigation is required, please issue interim report by 80-4-10.
D. Repair as necessary.

3. Investigation Results

The actuator was hand-carried in by Williams Research Corp. personnel, and the following initial portion of the investigation was witnessed by Williams Research Corp. and Government personnel. "As received" testing verified the complaint and the actuator was removed from the fuel control. Opening the actuator revealed a severely charred area about Q_6 and Q_7, two of the power transistors in the final motor drive stage. Removal of power to the final stage allowed trouble shooting of the signal conditioning and drive circuitry ahead of the power stage. This showed the entire circuitry with the exception of Q_6 and Q_7 to be operating normally. Subsequently, Q_6 and Q_7 were removed and tested on a transistor curve tracer. The 2N6301 (Q_7) was completely defective, behaving essentially as a short circuit in the circuit. The 2N6299 (Q_6)retained some semi-conducting characteristics, however, was severely deteriorated with respect to gain and also has increased in

THIS REPORT AS COMPLETED SHOULD INCLUDE AS NECESSARY
3. Test Results and/or Investigation Results
4. Conclusions
5. Corrective Action

APPROVAL

SUPERVISOR JLLeeson 80-4-10

SALES KAS 80-4-10

Q.A. JMG 80-4-11

SPECIAL HANDLING REPORT

EN 86853
S. Makulec
Page 2

3. Investigation Results (cont.)

resistivity. Since a high voltage spike can cause such transistor failure the transient suppression diodes in the circuit were also checked on the curve tracer, and proved to be functioning normally.

4. Conclusions

As the transient suppression circuitry was still functional, we assume that no voltage spikes reached the transistors in excess of their specification limit. Therefore, it is concluded at this time that the first transistor to fail (Q_7), failed during operation for unknown reasons. This failure would then allow, when Q_8 was turned on normally, direct, high current flow from the 28 volt buss, through both transistors, to ground. Such current flow would be well in excess of normal, and would cause severe heating in both transistors, in this case precipitating deterioration of performance in Q_8. Since the actuator would not be responding to the input signal, this could be a long term condition. It should be noted that this sequence of events is a hypothetical, but very probable one. The cause of the failure in Q_7 could be due to a number of things, as yet undetermined. The subject transistors have been sent to the manufacturer, Motorola, for failure analysis. Since both transistors were subjected to severe thermal overstress, this analysis may not yield conclusive results, since some of the defects that are possible causes may also be the results of the thermal overstress.

5. Corrective Action

Since a pattern of recurring failures is not established, and since further evidence may be forthcoming, no corrective action is anticipated at this time. Also, it should be noted that these devices are slated for replacement upon approval of proposed changes to conform with nuclear requirements. The replacement devices will be processed in accordance with JANTX standards. This would enhance reliability, since the JANTX processing is not available on the present devices. A supplement to this report will be issued when further information is available.

rg J.L.

JULIUS ALBERANI

SPECIAL HANDLING REPORT

EN 86853
Supp. 1

SUBJECT: Additional Failure Analysis - Vendor information.

FROM: Steve Makulec

DATE: May 20,1980

FINAL REPORT

TRANSISTOR FAILURE IN ENG. 828'S FUEL CONTROL.

Abstract:

The original Special Handling Report covered the analysis of an X83209 Power Lever Actuator failure. The vendor failure analysis is now available, which points out manufacturing defects in the failed semiconductors which likely led to the overstress of the part.

Investigation Results/Conclusions:

The vendor's analysis of the failed parts (attached) substantiates the condition of the parts as removed from the actuator and gives a synopsis of further findings with the Motorola product engineer clarified the reported phenomena. The premise that the 2N6301 type transistor failed first and thus caused the failure of the 2N6299 type transistor still appears to be valid, although it can't be proven conclusively. Various voids were found in the construction of both transistors. These devices are built in a stacked up fashion, with the silicon chip (die or dice) soft soldered to a copper heat spreader button, which is then soft soldered to the actual transistor case (header). The soldered areas are accomplished with a solder preform, and subsequent heating to melt the preform and establish a bond. As such, Motorola indicates that it is difficult to achieve a completely void free construction. Because of that, they perform a Safe Operating Area (SOA) test on the completed parts; which puts adequate stress on the parts to cull out parts with excessive voiding, and hence inadequate thermal conductivity. This testing is done in a manner similar to testing in accordance with MIL-S-19500. As they perform this random sampling procedure the resultant typical Acceptance Quality Level (AQL) is 0.28%, i.e., statistically no more than 0.28% of the devices shipped would be defective with respect to the tested parameter. This SOA test is performed at full power capability for 0.5 seconds, which is a much higher stress level than the application.

Materials analysis showed the 2N6301 type (WGC P/N 1686-682) had approximately 10% voids under the silicon die, and 50% voids under the copper button. This presumably was the transistor that failed first and was verified to be shorted. Also, evidence of melting on the die surface indicates severe overheating. Motorola's assessment of this device and the existing voiding is that passing the SOA test would have been unlikely. It therefore represents a random escape through Quality Assurance testing. No testing is done at Woodward Governor Company that would have caught this, and the additional processing imposed by the drawing (High Temperature Reverse Bias-HTRB Burn-in) does not stress the part in a manner that would cull out such a problem.

Williams Research Corporation

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SPECIAL HANDLING REPORT

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Investigation Results/Conclusions -cont.

The 2N6299 WGC P/N 1686-680) was found to have approximately 50% voiding under the silicon die, generally in the center of the die. Although this is not desirable, the Motorola people believe the device would have passed the SOA test. The device as returned to Motorola was verified to be severely degraded in performance.

Given the above information, the 2N6301 type transistor appears to have been the weak part in the system. Since it is failed shorted, the premise that it failed first, causing subsequent overstress and degradation of the 2N6299 type transistor, seems to be upheld. The expected sequence of events, then, is as follows: The 2N6301 fails first, presumably while actuated and driving the motor. When the position is as necessary the drive to the motor is cut off and at some point in time re-energized to drive the motor in the opposite direction. That turns the 2N6299 on and current is drawn through it and the shorted 2N6301. Since this current is shunted directly from supply to ground the motor does not move, and the control circuit is not satisfied. This provides for a long term high current flow through the transistors, causing the thermal overstress noted.

The major fault in the above train of events is that at the applied stress levels, which are well below that of the SOA test, it is very difficult to assess whether or not the 2N6301 would have failed. However, since all other parts of the circuit including transient protection, were functional, it is a probable sequence of events.

Recommendations:

The stated AQL of 0.28% for the SOA testing indicates the risk of an individual part getting through this system while defective. As there are five of these devices per actuator the probability of a defective part in a unit is 1.4%. However, note that an AQL level is an indication the maximum number of defectives, and that in the application the stress is much lower than the SOA test (less than 7% versus 100% stress). Thus, a more reasonable and yet still conservative estimate of the probability of a deficiency existing that would result in a overstress condition is less than 1% for the actuator. Since a determination of the actual condition of the transistors can't be made in the field it is recommended that the customer use the above figure as a guideline to compare to his acceptable risk on a given unit. If the risk is deemed unacceptable, the alternative is return and disassembly to a point where the transistors condition can be assessed and replaced if necessary.

Attachments: Motorola Product Analysis Report PL-410*001/PL-411*001
(To original only)

SEM/rg
80-4-20

Steve Makulec

MOTOROLA INC.
Semiconductor Group
ALBERANI
Bill SCHRADER

RELIABILITY AND QUALITY ASSURANCE DEPARTMENT

PRODUCT ANALYSIS REPORT

#369 REPORT NO. PL-410°001/PL-411°001

PREPARED FOR	REFERENCE	DEVICE TYPE	LOT NUMBER	CUSTOMER PART NUMBER
WOODWARD GOVERNOR (WDGOV)		2N6301, 2N6299		
	POINT OF FAILURE: In Equipment in field (DTX)			
	REASON FOR REJECTION: C-E shorts			
FOR: Con Webb	TYPE OF REQUEST: ☒ FIELD ☐ HIREL QA ☐ RELIABILITY ☐ RMR ☐ OTHER			

FAILURES	QUANTITY RECEIVED	LOT SIZE	SAMPLE SIZE	ACCEPTANCE LIMIT
-	2	-	-	-

CODE	DATE CODE(S)	SERIAL NUMBER(S)
DM/Loc. 8	742, 717	1, 2

BACKGROUND:

Two power darlingtons in the aluminum TO-66 case were applied as drivers in a fuel control power lever actuator circuit in the Cruise Missile. The failure occurred during official testing under military surveillance. Subsequent failure analysis of the circuit showed no associated component failures. The devices were protected with 1N5631 40 volt zener supressors and operated in an environment EM.I. protected to 30,000 MZ. The transistors were received decapped.

INVESTIGATION:

Parametric measurements with a curve tracer verified the shorted condition in the 2N6301 and degraded gain in the 2N6299. Microscopic examination of the die surfaces revealed evidence of severe overheating, resulting in a partial melting at the emitter contact areas (arrow, Photo 1). Furthte investigation revealed large voids beneath the dice of both parts (Photo 2). Voids were also found beneath the copper heat spreader buttons.

CAUSE:

Poor thermal conductivity between the dice and headers has allowed the temperature of the dice to rise until destructive melting occurred in the emitter contact regions.

CORRECTIVE ACTION:

Voiding beneath the die bonds and copper button bonds are detected by an SOA test. At the time of manufacture, this product was sample tested to a 30V, 2.5A, 0.5 second specification. These parts represent random escapes that passed customer testing. A new steel package has been applied to this product line, and its high-temperature braze is consistently void-free. It is suggested that these new style parts be employed whenever possible. One hundred percent SOA test may be guaranteed with an SJ specification, and a JAN version of this part would guarantee exceptional quality.

PERFORMED BY		REPORT APPROVED BY	
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Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

To: J. ALBERANI
FROM: B. SCHRADER

MOTOROLA INC.
Semiconductor Group

RELIABILITY AND QUALITY ASSURANCE GROUP

PRODUCT ANALYSIS REPORT NUMBER	PAGE	OF
PL-410*001/PL-411*001		

PREPARED FOR	REFERENCE	DEVICE TYPE	LOT NUMBER
WOODWARD GOVERNOR			

Photo 1. Optical micrograph of emitter region of 2N6301 device. Partial melting has occurred. (45X)

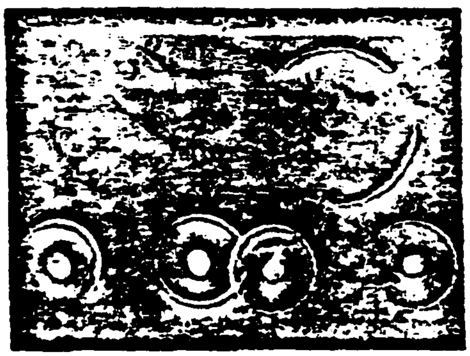

Photo 2. X-ray shadowgraphs of 2N6301 (left) and 2N6299 (right) die bonds (square regions). Voids beneath dice are unusually large. 2N6301 also has large void beneath copper button (arrow). (6X)

APPENDIX G

OIL SAMPLE ANALYSIS DATA

This appendix contains oil sample analysis laboratory reports provided to WRC by AEDC. This information was used in compiling Table 3-V of this report.

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH
LABORATORY SECTION REPORT

Sverdrup ARO, Inc.

Requested by W. C. Gobbell ETF/TT

Report No. 0041-8

Material Submitted T-5, 23699B Oil, Pre Mission Calibration
~~Engine Ser.~~ 828-100 , Time - 2200 , Place - Engine
Collected 4-1-80 , Total Run Time - ---

Date Completed 4-2-80 P.S.B.

Work Auth. E411-18C

Date In 4-2-80

Date Out 5-7-80

By H. Ivy, Jr. and P. S. Byrom

Instructions:

Determine Wear Metals by Atomic Absorption and Emission Spec.; also, Specific Gravity at 75°F.

Results:

Al	- N.D.	Ti	- N.D.
Fe	- N.D.	Cu	- N.D.
Si	- N.D.	Mg	- N.D.
Cr	- N.D.	Sn	- N.D.
Ni	- 0.2	Pb	- 0.3
Ag	- N.D.		

Specific gravity @75°F. = 0.969.

OIL SAMPLE DRAINED FROM ENGINE 828-6 ON 4-1-80
FOLLOWING PRE HOT-DAY MISSION CALIBRATION RUN.
ENGINE HOT TIME ON SAMPLE ; 1 HR, 8 MIN.

Remarks:
N.D. - Not Detected.
A.A. - Results expressed in ppm.
A.A. - Results phoned in 4-2-80 Time 1430 hrs. To Gobbell.
Emission Spec. results attached.

QUALITY CONTROL TSD APPROVED

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH

Sverdrup | ARO Inc

SEM ENERGY DISPERSIVE X-RAY AND SPECTROGRAPHIC ANALYSIS REPORT

Sample No. 0041-8 Date In 4-2-80
Plate No. 03160 Date Out 5-7-80
Submitted By W. C. Gobbell ETF/TT Work Authorization E411-18C

☐ SEM ☒ SPECTROGRAPH

Sample Description 23699 Oil T-5 - Pre-Mission Calibration (Engine)

Method of Analysis with a Statement of Accuracy:
Quantitative ______ Semi-Quantitative +10-30% Qualitative ______

Results	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.
Ag	—						
Al	0.02						
B							
Ba							
Be							
Bi							
Ca							
Cb							
Cd							
Cl							
Co							
Cr	—						
Cu	0.03						
Fe	—						
K	—						
Mg							
Mn							
Mo							
Na							
Ni	—						
P							
Pb							
S							
Si	0.05						
Sn	—						
Ti	—						
Zn							
Pb	—						

Remarks:

1 – Micrograms/Gram
2 – Percentage
3 – ND – Not Detected
4 – LLD – Lower Limit of Detectibility
5 – ZAF – SEM Analysis
6 – ML – SEM Analysis

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH
LABORATORY SECTION REPORT

Sverdrup | ARO, Inc

Requested by W. C. Gobbell ETF/TT	Report No. 0043-109
	4/28 P.S.B.
Material Submitted T-5, 23699B Oil, Post Hot Day Mission Engine S/N 828-113 , Time - 2230 , Place - Engine Collected 4-12-80 , Total Run Time - ?	Date Completed 4-14-80
	Work Auth. E41I-18C
Date In 4-14-80	Date Out 5-8-80
By H. Ivy, Jr. and P. S. Byrom	

Instructions:

Determine Wear Metals by Atomic Absorption and Emission Spec.; also, Specific Gravity at 75°F.

Results:

Al	- 0.7		Ti	- N.D.	
Fe	- 1.6		Cu	- 0.1	
Si	- N.D.		Mg	- N.D.	
Cr	- 0.2		Sn	- N.D.	
Ni	- N.D.		Pb	- N.D.	
Ag	- N.D.				

Specific gravity @ 75°F = 0.969.

OIL DRAINED FROM ENGINE 828-6 ON 4-12-80 AFTER HOT-DAY MISSION. 5HR, 11 MIN HOT TIME.

QUALITY CONTROL TSD ARO, INC.-AEDC

Remarks:
N.D. - Not Detected.
A.A. - Results expressed in ppm.
A.A. - Results phoned in 4-14-80 Time 1435 hrs. To Mitchell.

Emission Spec. results attached.

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH

Sverdrup | ARO Inc

SEM ENERGY DISPERSIVE X-RAY AND SPECTROGRAPHIC ANALYSIS REPORT

Sample No. 0043-109 Date In 4-14-80
Plate No. 03165 Date Out 5-8-80
Submitted By W. C. Gobbell ETF/TT Work Authorization E411-18C

☐ SEM ☒ SPECTROGRAPH

Sample Description ____

Method of Analysis with a Statement of Accuracy:
Quantitative ____ Semi-Quantitative + 10-30% Qualitative ____

Results	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.
Ag	0.06						
Al	0.4						
B							
Ba							
Be							
Bi							
Ca							
Cb							
Cd							
Cl							
Co							
Cr	0.2						
Cu	0.1						
Fe	0.6						
K	0.04						
Mg							
Mn							
Mo							
Na							
Ni	0.1						
P							
Pb							
S							
Si	0.4						
Sn	--						
Ti	0.1						
Zn							
Pb	0.05						

Remarks: Results expressed as ppm

1 – Micrograms/Gram
2 – Percentage
3 – ND – Not Detected
4 – LLD – Lower Limit of Detectibility
5 – ZAF – SEM Analysis
6 – ML – SEM Analysis

D. W. Baker

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT

LABORATORY SECTION REPORT

Requested by W. C. Gobbell, ETF/TT

Report No. 0043-147

Material Submitted T-5, ~~2801-0~~ 23699 Oil, Cold Day Mission Post Run #

Engine S/N 828-119, Time - 0030, Place Engine Collected - 4/15/80, Total Run Time - -

Date Completed 4/16/80 4/28 PSB

Work Auth. E411-18C

Date In 4/16/80

Date Out 5/5/80

By Herman Ivy, Jr. & P. S. Byrom

Instructions:

Determine Wear Metals by Atomic Absorption.

Total acid number, mg KOH per gram sample.

Results:

Al - N.D.	Ti - N.D.
Fe - 0.4	Cu - 0.1
Si - N.D.	Mg - N.D.
Cr - 0.1	Sn - N.D.
Ni - N.D.	Pb - N.D.
Ag - 0.04	

Specific gravity @ 75°F = 0.971

OIL SAMPLE TAKEN FROM ENGINE 828-6 ON 4-15-80 FOLLOWING COLD DAY MISSION TEST. ENGINE HOT TIME ON THIS SAMPLE; 5HR, 49 MIN.

Remarks:

N.D. - Not Detected.
Results expressed in ppm.

Phoned in 4/16/80 Time 1055 hrs. To Mitchell.

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH

Sverdrup | ARO Inc

SEM ENERGY DISPERSIVE X-RAY AND SPECTROGRAPHIC ANALYSIS REPORT

Sample No. 0043-147 Date In 4/16/80
Plate No. 03166 Date Out 5/5/80
Submitted By W. C. Gobbell, ETF/TT Work Authorization E41I-18C

☐ SEM ☒ SPECTHOGRAPH

Sample Description 236998 (7808G) oil T5 - Cold Day Mission - Container #828-119

Method of Analysis with a Statement of Accuracy:
Quantitative ______ Semi-Quantitative + 10-30% Qualitative ______

Results							
Ag	0.1						
Al	0.3						
B							
Ba							
Be							
Bi							
Ca							
Cb							
Cd							
Cl							
Co							
Cr	0.08						
Cu	0.06						
Fe	0.6						
K							
Mg	0.02						
Mn							
Mo							
Na							
Ni	0.08						
P							
Pb							
S							
Si	0.2						
Sn							
Ti	0.02						
Zn							
Pb	-						

Remarks: Results expressed as ppm.

1 — Micrograms/Gram
2 — Percentage
3 — ND — Not Detected
4 — LLD — Lower Limit of Detectibility
5 — ZAF — SEM Analysis
6 — ML — SEM Analysis

D. W. Baker

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT

LABORATORY SECTION REPORT

Requested by W. C. Gobbell, ETF/TT — Report No. 0043-156

Material Submitted T-5, ~~7000-8~~ 23699 Oil, Post Run Mission Calibration — Date Completed 4/17/80 4/28/80

Engine S/N 828-122 Time - 1900, Place Engine

Collected - 4/16/80, Total Run Time - -- — Work Auth. E411-18C

Date In 4/17/80 — Date Out 5/5/80

By Herman Ivy, Jr. & P. S. Byrom

Instructions:

Determine Wear Metals by Atomic Absorption.

Results.

Al - N.D.	Ti - N.D.
Fe - 0.2	Cu - N.D.
Si - N.D.	Mg - N.D.
Cr - N.D.	Sn - N.D.
Ni - N.D.	Pb - 0.1
Ag - N.D.	

Specific gravity @ 75°F = 0.971

OIL SAMPLE TAKEN FROM ENGINE 828-6 ON
4-16-80 FOLLOWING ~~POST~~-COLD-DAY MISSION CALIBRATION.
ENGINE HOT TIME ON THIS SAMPLE; 26 MIN.

Remarks: N.D. - Not Detected.
Results expressed in ppm.

Phoned in 4/18/80 Time 1455 To Mitchell.

Williams Research Corporation

CMEP 95-4120
Report No. 79-106-39

TECHNICAL SUPPORT DEPARTMENT
CHEMICAL & METALLURGICAL BRANCH

Sverdrup | ARO Inc

SEM ENERGY DISPERSIVE X-RAY AND SPECTROGRAPHIC ANALYSIS REPORT

Sample No. 0043-156 Date In 4/17/80
Plate No. 03166 Date Out 5/5/80
Submitted By W. C. Gobbell, ETF/TT Work Authorization E41I-18C

☐ SEM ☒ SPECTROGRAPH

Sample Description 23699 oil T5 Post Mission Calibration. Container #828-122

Method of Analysis with a Statement of Accuracy:
Quantitative ______ Semi-Quantitative + 10-30% Qualitative ______

Results	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.
Ag	0.03						
Al	0.05						
B							
Ba							
Be							
Bi							
Ca							
Cb							
Cd							
Cl							
Co							
Cr	0.03						
Cu	0.03						
Fe	0.3						
K	-						
Mg							
Mn							
Mo							
Na							
Ni	0.03						
P							
Pb							
S							
Si	0.05						
Sn	-						
Ti	-						
Zn							
Pb	-						

Remarks: Results expressed as ppm

1 – Micrograms/Gram
2 – Percentage
3 – ND – Not Detected
4 – LLD – Lower Limit of Detectibility
5 – ZAF – SEM Analysis
6 – ML – SEM Analysis

D. W. Baker